AD-A085 479 ROYAL AIRCRAFT ESTABLISHMENT FARNBOROUGH (ENGLAND) F/G 17/7
CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND D--ETC(U)
MAY 79 J M JONES
UNCLASSIFIED RAE-TR-79052-VOL-2 DRIC-BR-73762 NL

1 of 2
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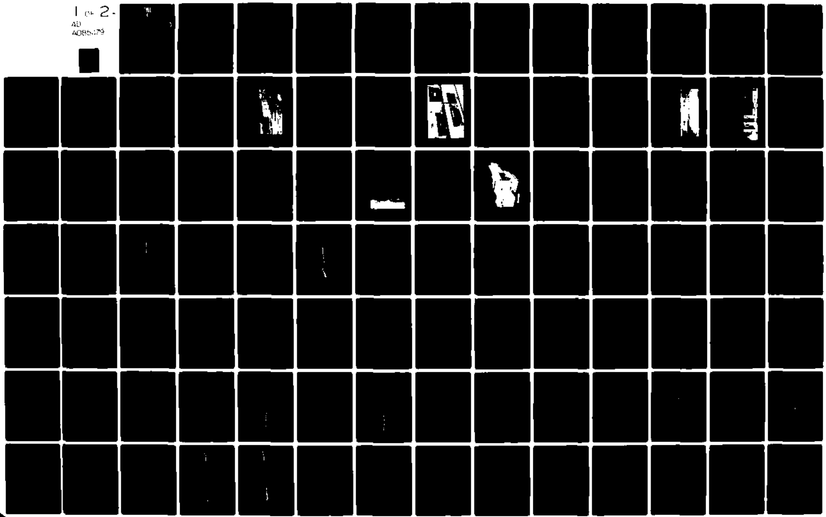

LEVEL III

A085478

2 B.S.

ROYAL AIRCRAFT ESTABLISHMENT

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9 Technical Report 79052

11 May 1979

# 6 CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND DEVELOPMENT PROGRAMME 1974 TO 1978.

Volume 2.

by

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10 J.M. Jones

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VOLUME 2

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14 RAE-TR-79052-VOL-2

Procurement Executive, Ministry of Defence
Farnborough, Hants







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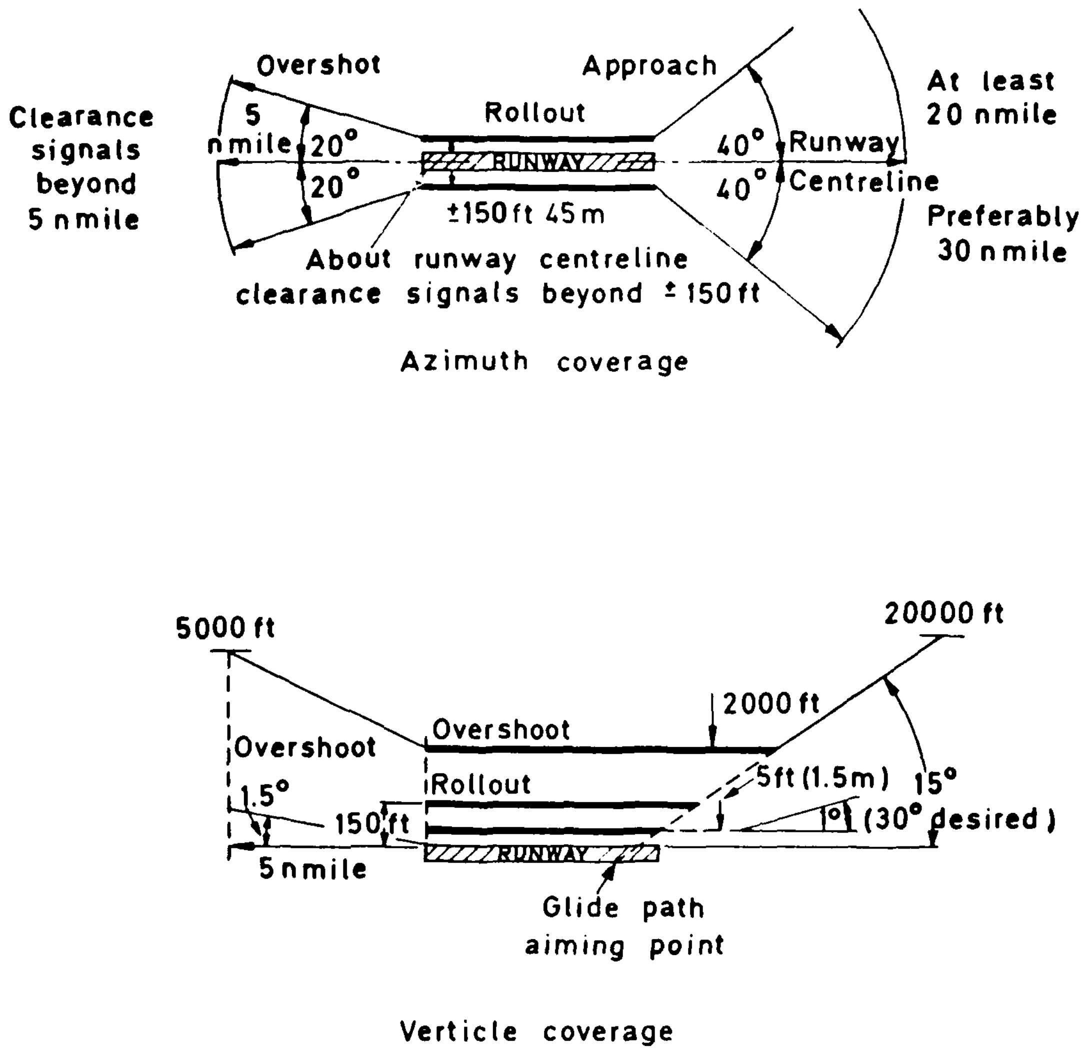


Fig 1.1 Coverage requirements for MLS

Fig 2.1

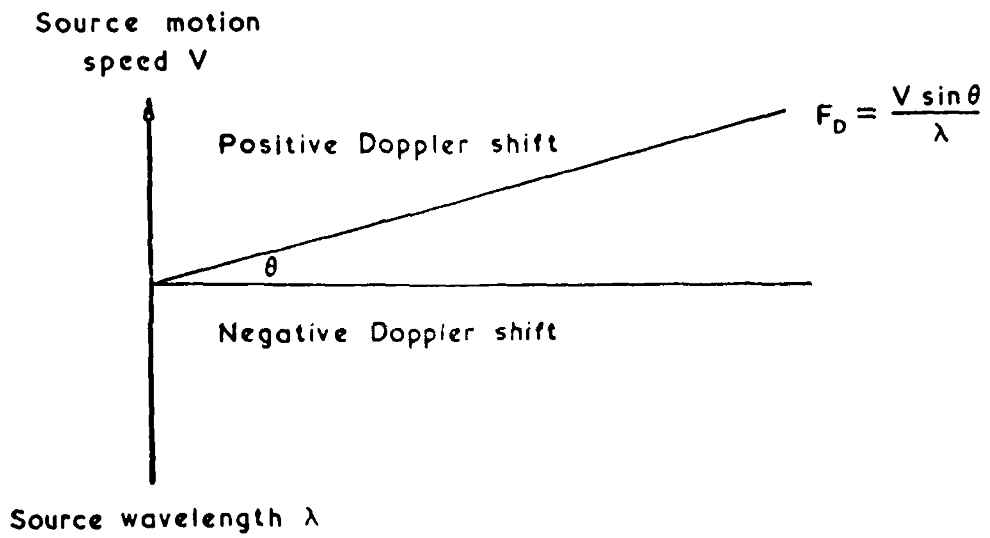


Fig 2.1 Doppler effect

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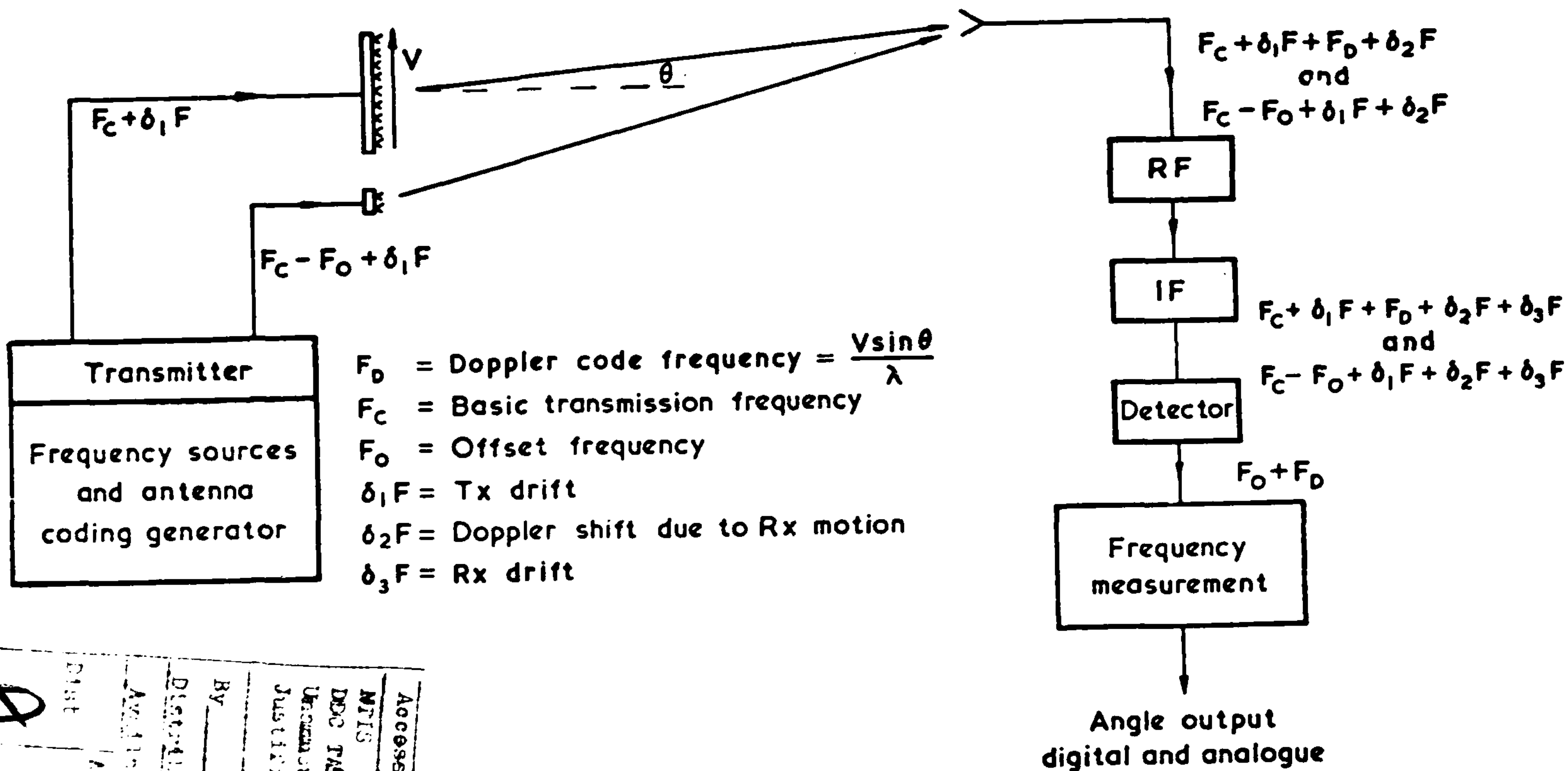
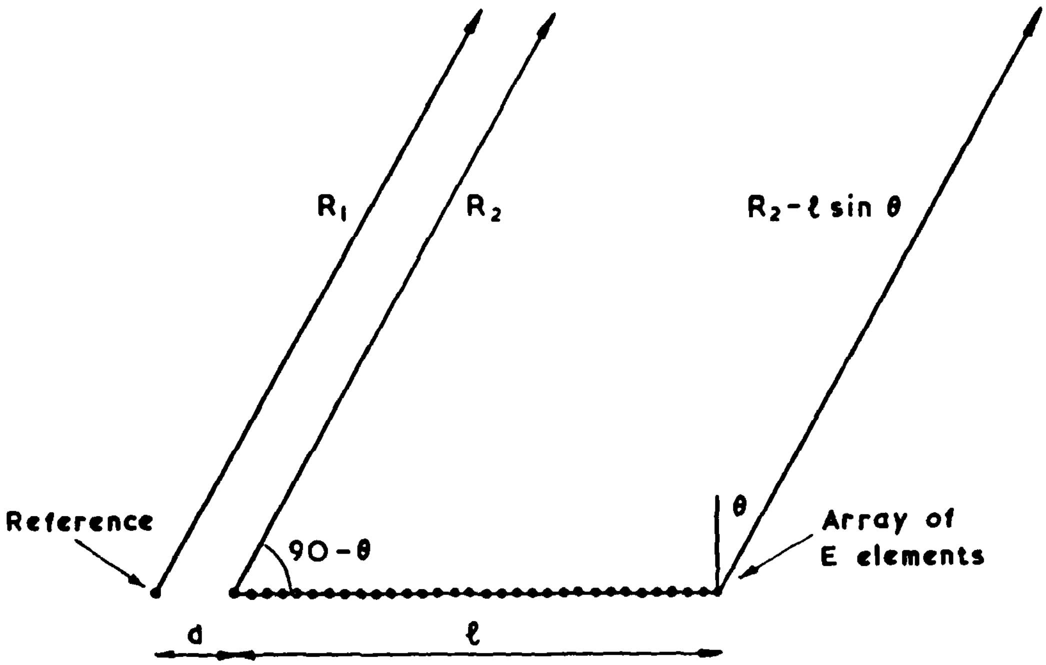



Fig 2.2 Basic system — block diagram

Fig 2.3




$d = D\lambda \quad \ell = L\lambda$

Reference transmission $\exp j\,\omega_R t$

Array signal 'left to right' $\exp j\,(\omega_{A_1} t + \alpha)$

Array signal 'right to left' $\exp j\,(\omega_{A_2} t + \beta)$

Fig 2.3 Propagation geometry

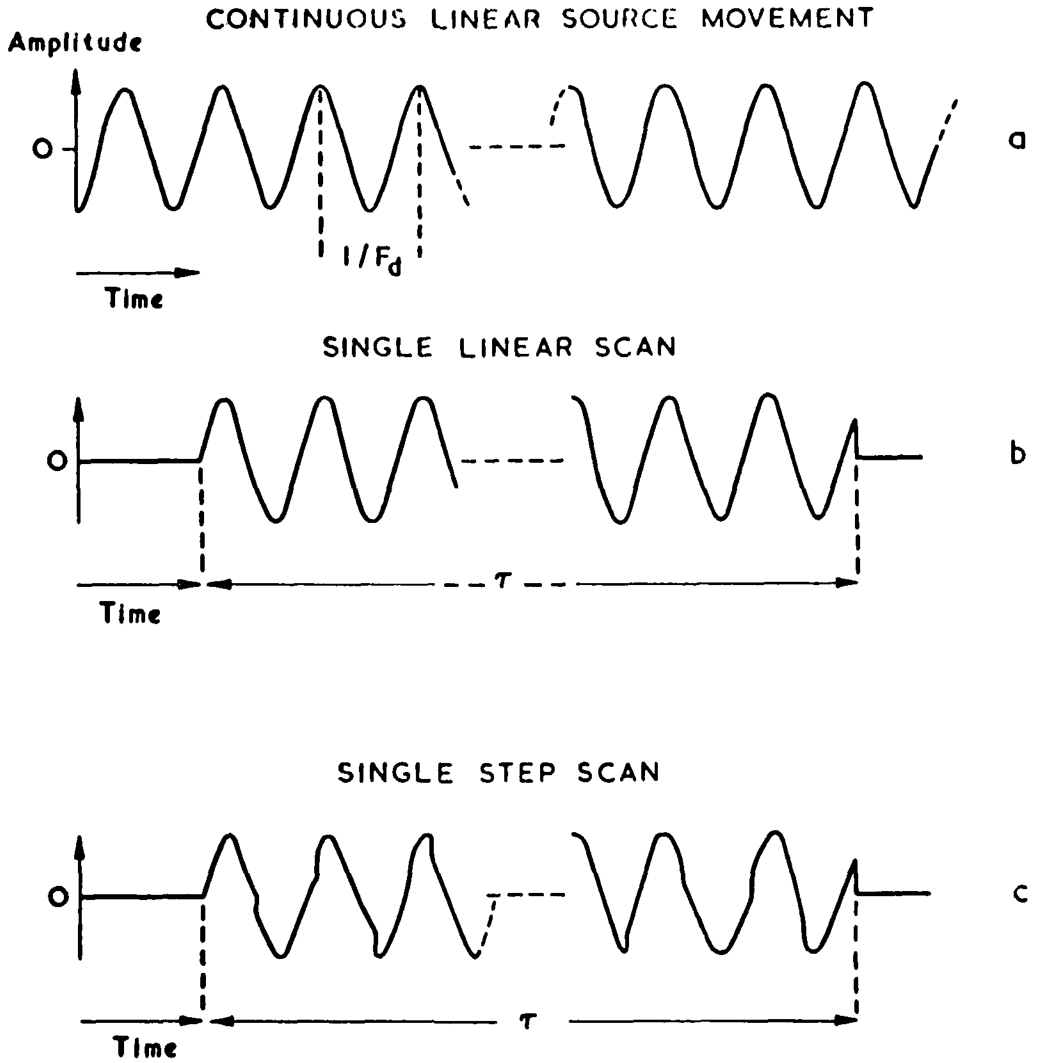



Fig 2.4 Doppler signal waveforms

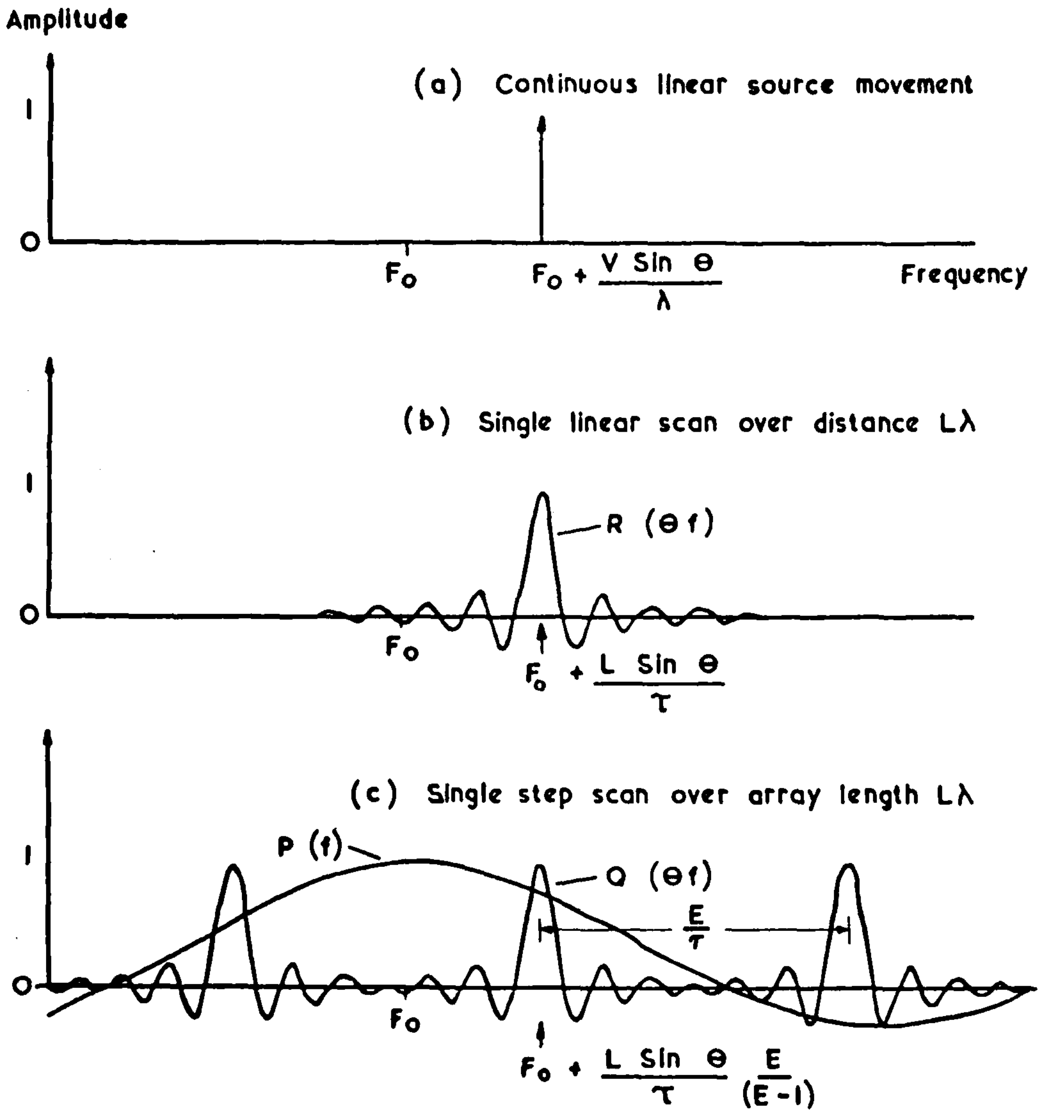



Fig 2.5 Doppler signal spectra

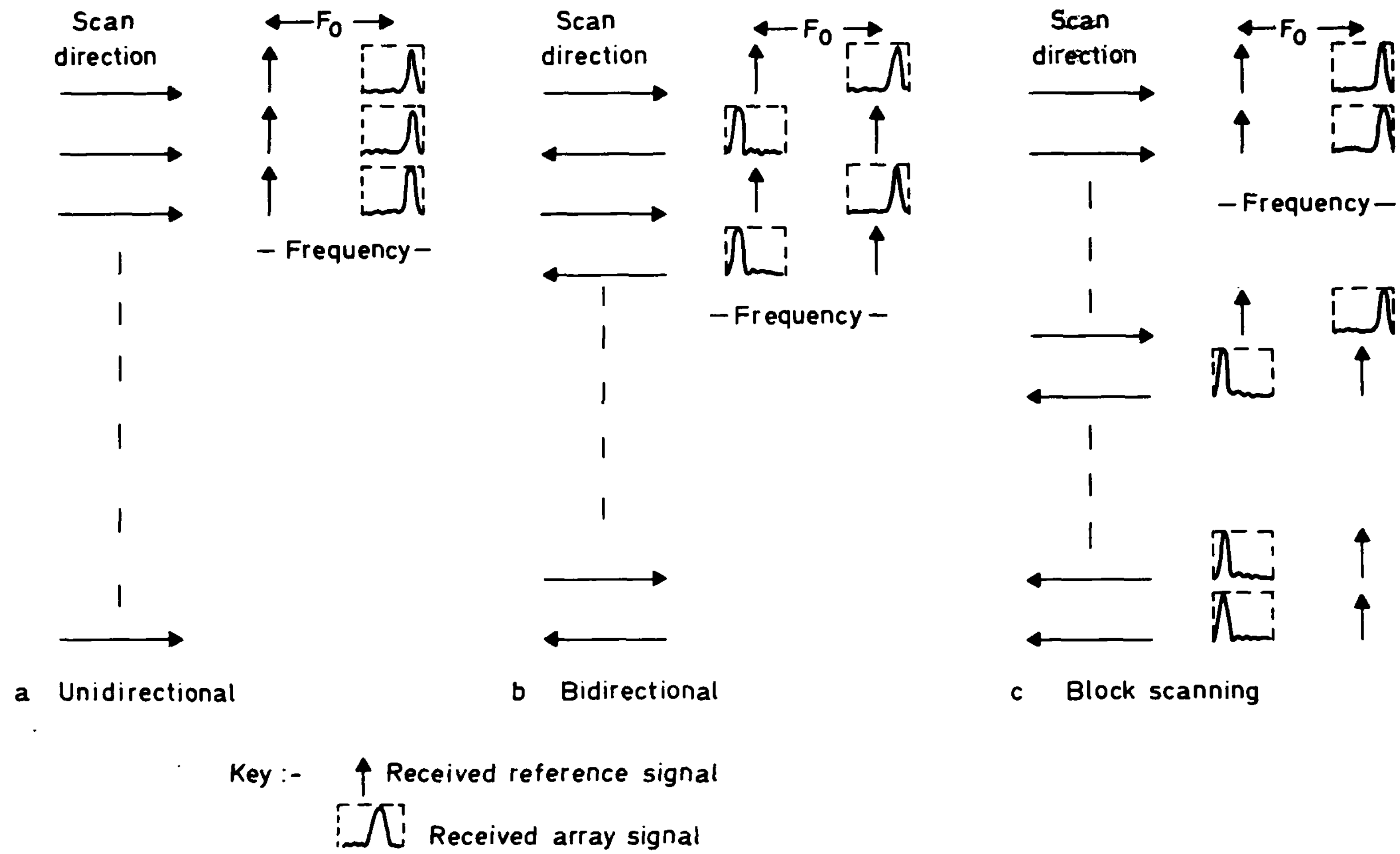



Fig 2.6 Typical angle transmission formats

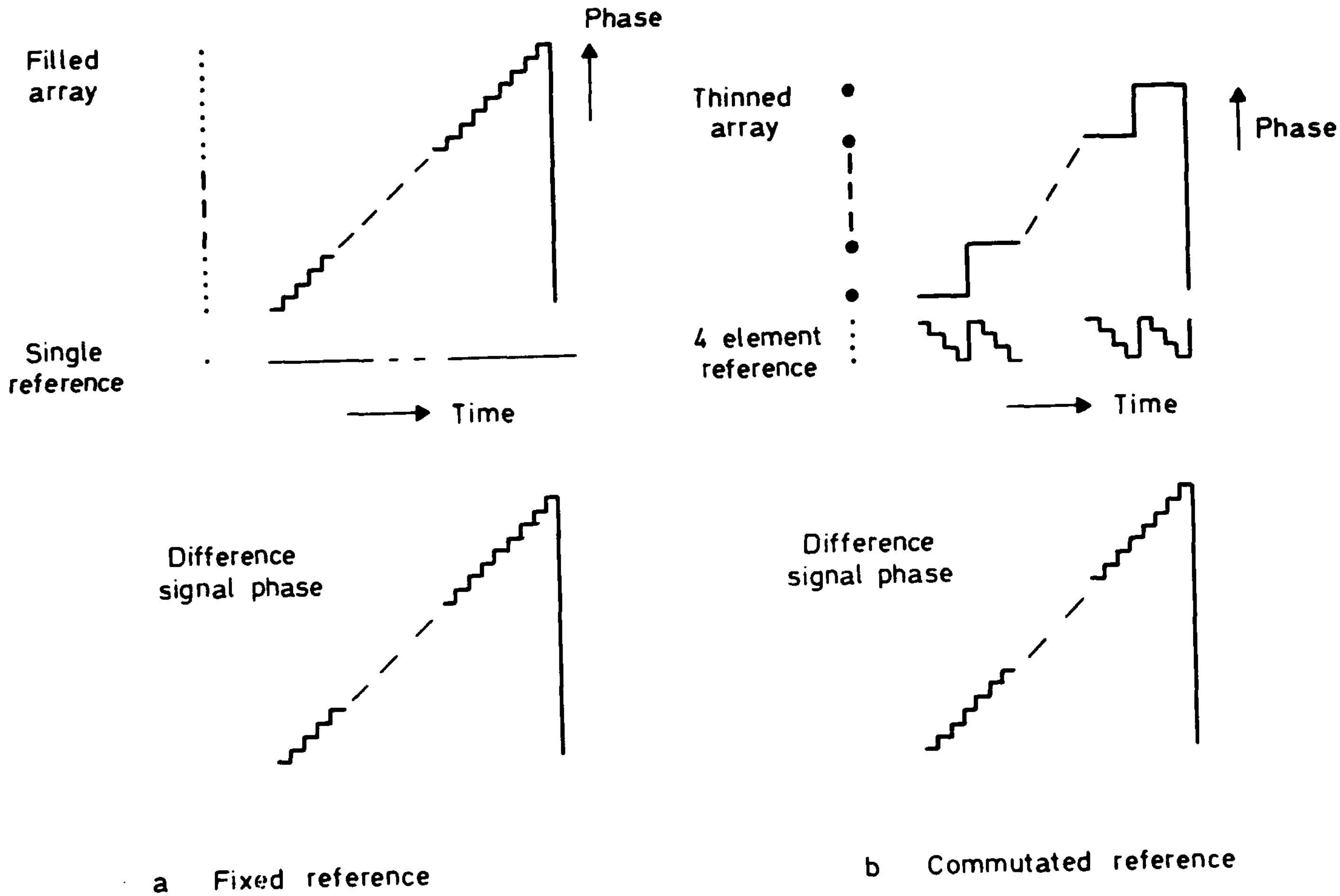



**Fig 2.7 Fixed and commutated reference systems**

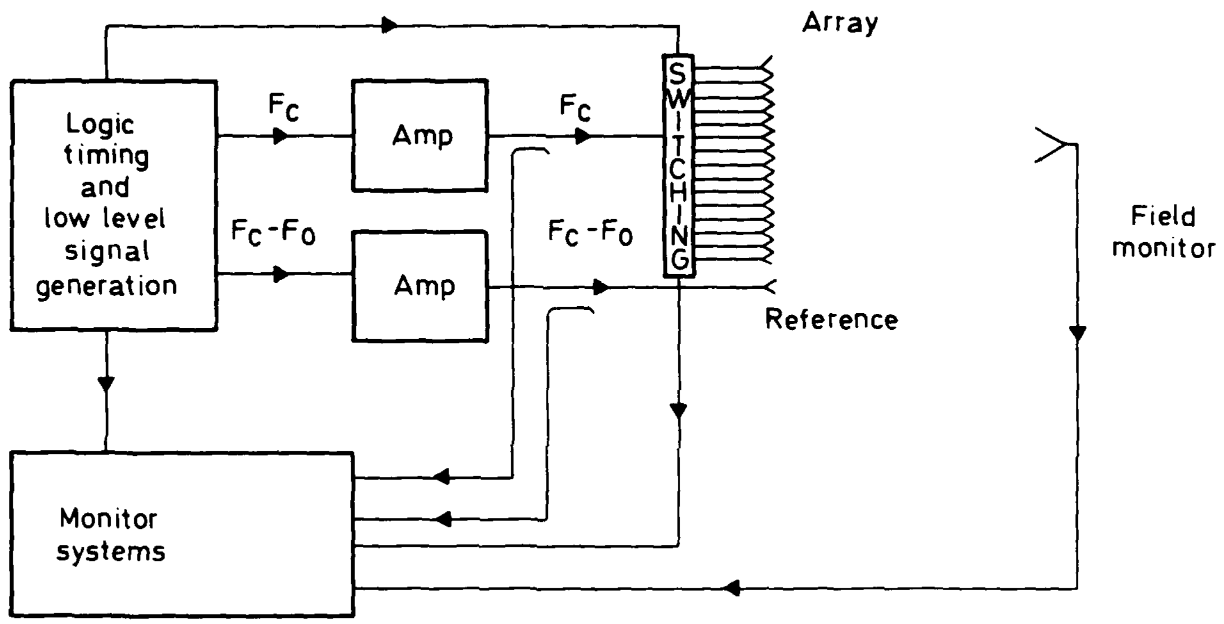



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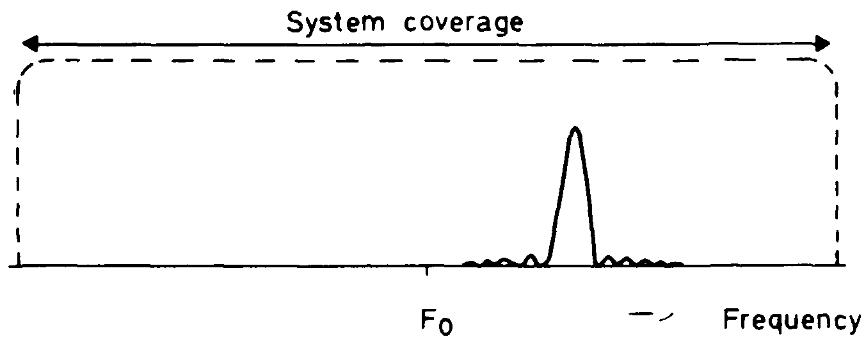
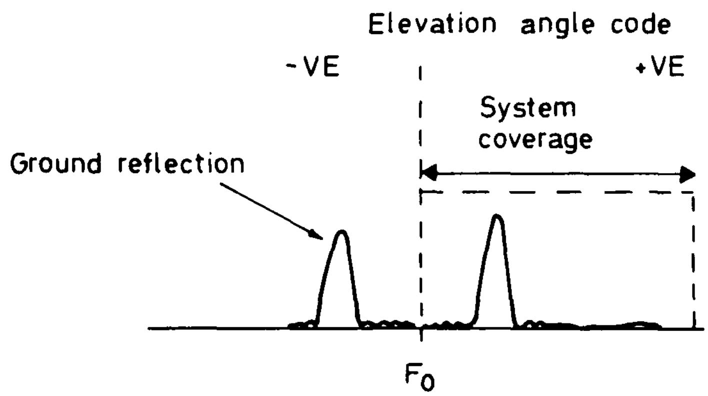
Fig 2.8 The basic DMLS ground system

Fig 2.9a&b




2.9a Azimuth system




2.9b Elevation system

**Fig 2.9a&b Received difference signal spectra**

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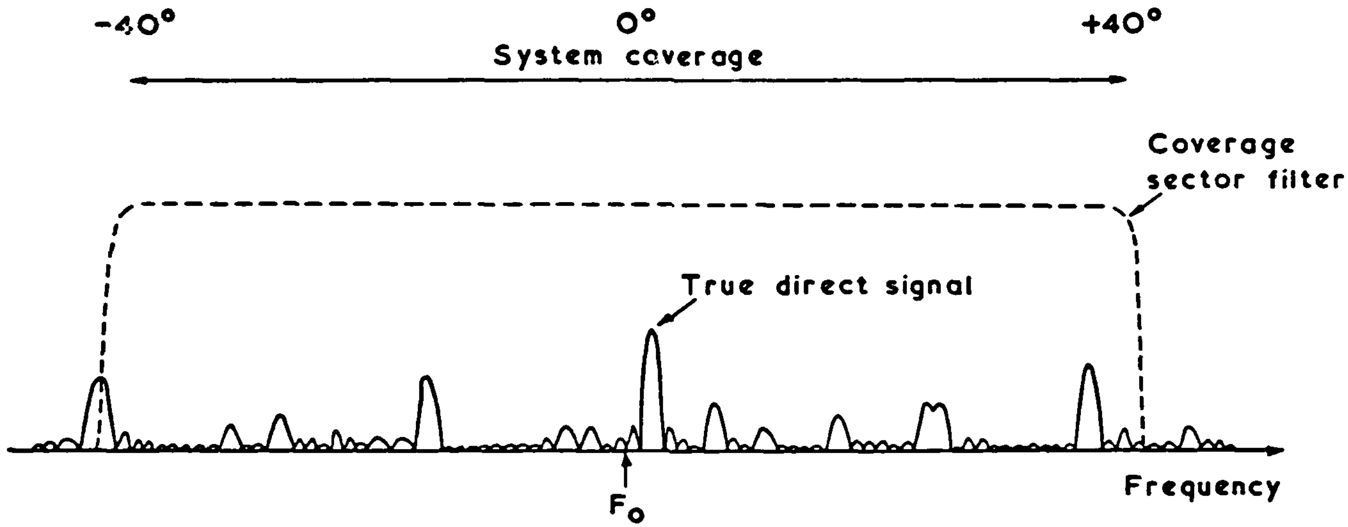


Fig 2.10 Doppler signal with multipath

Fig 2.11

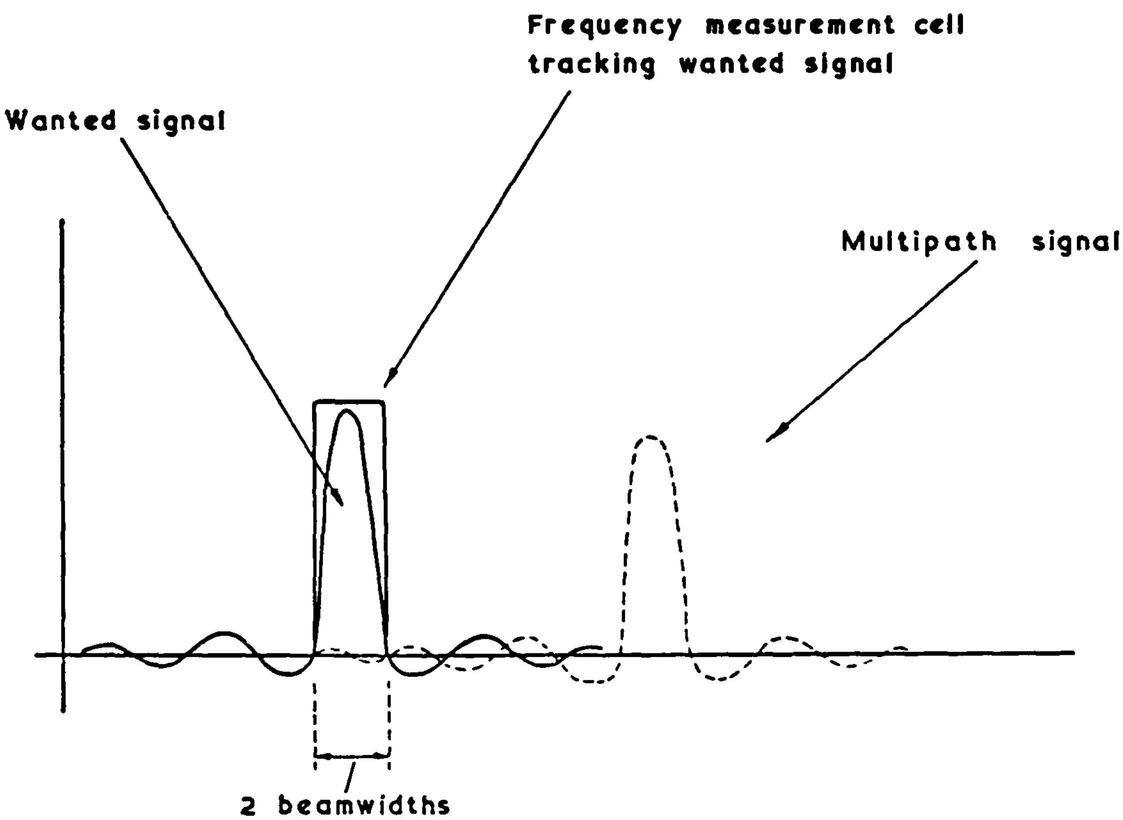


Fig 2.11 Separation of wanted signal using frequency cell

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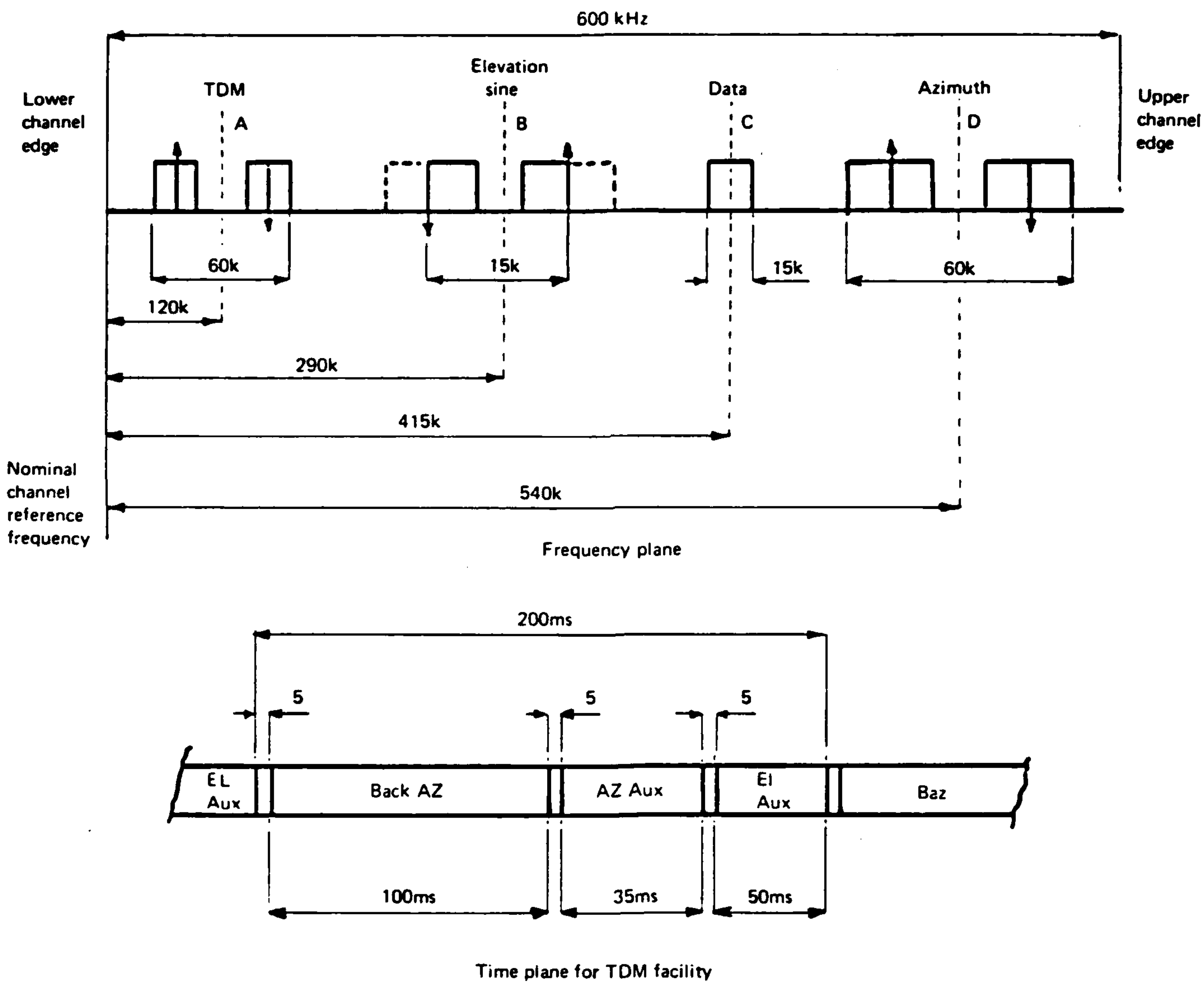


Fig 3.1 Hybrid format

Fig 3.2

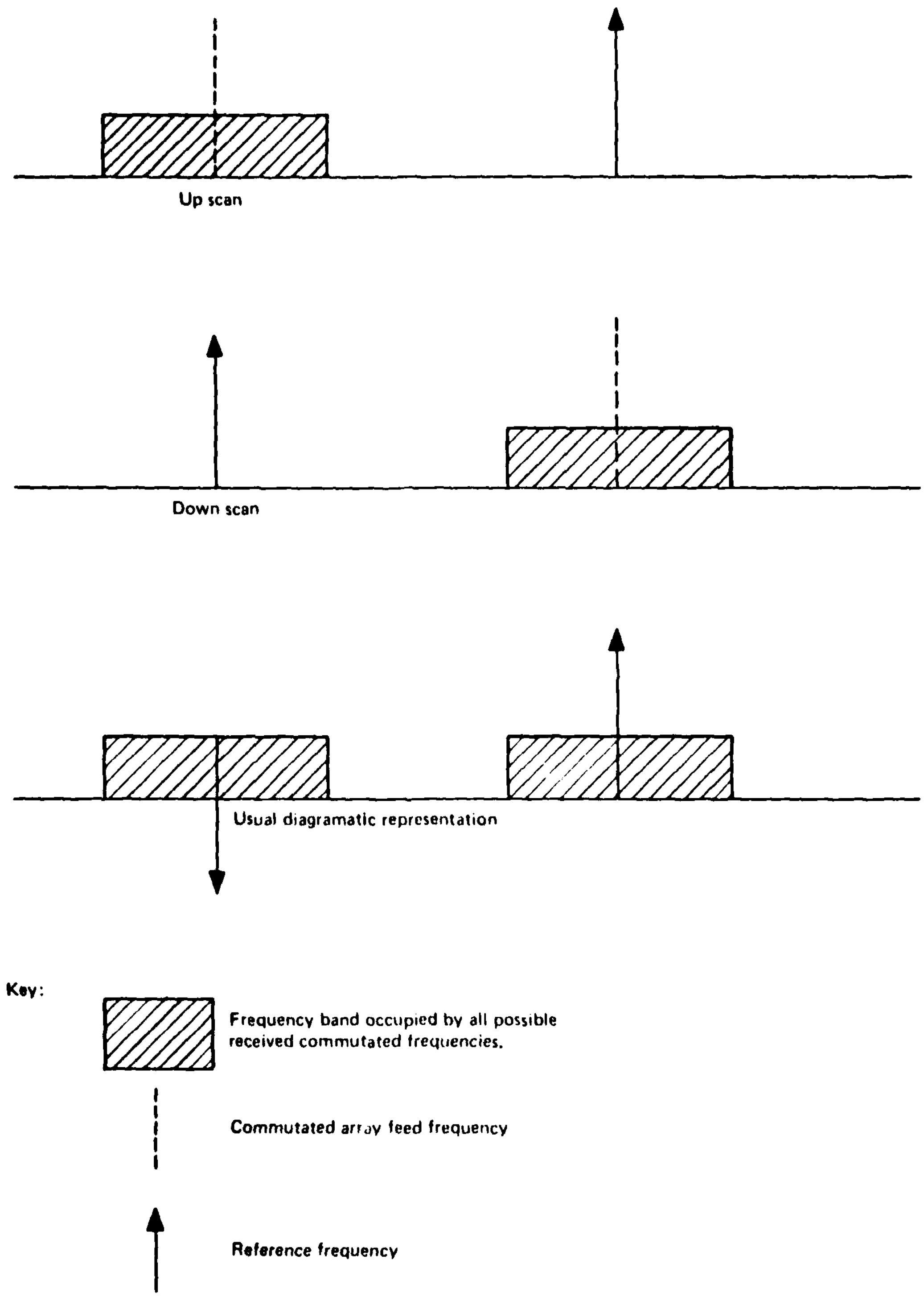


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Fig 3.2 Frequency interchange method of providing offset frequency

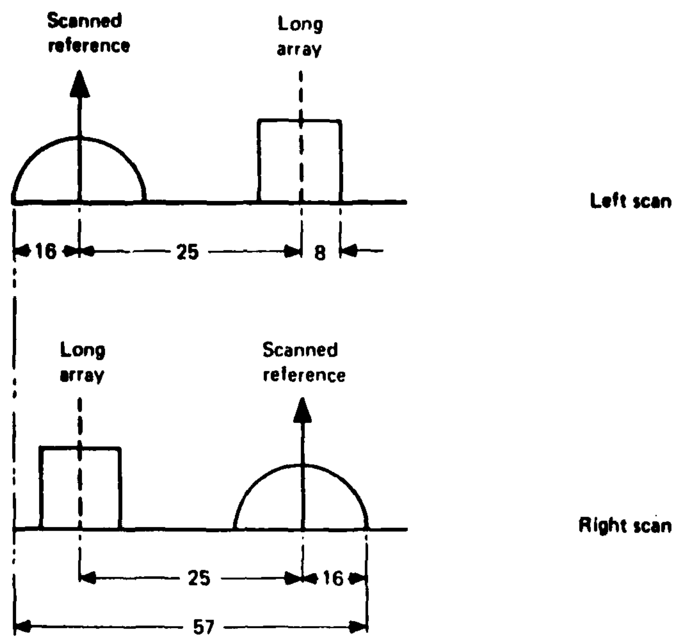


Fig 3.3 Azimuth sub-channel frequencies (kHz)

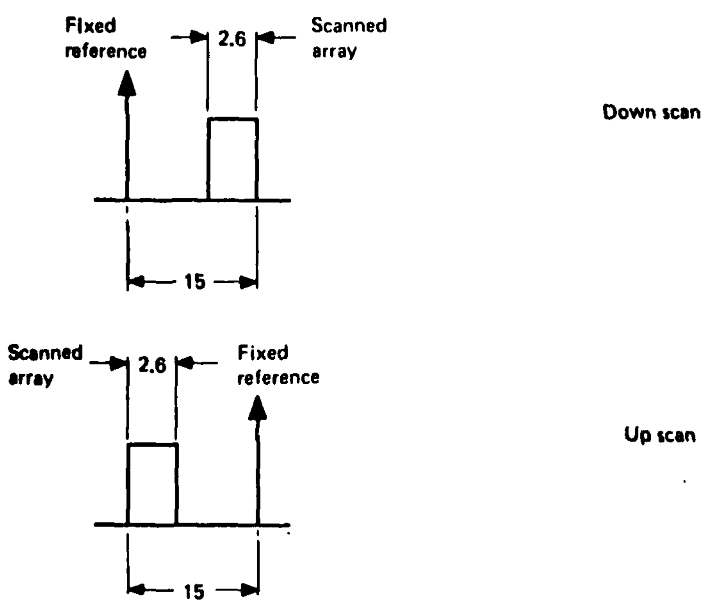


Fig 3.4 Elevation sub-channel frequencies (kHz)

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Fig 3.5 120 wavelength azimuth antenna

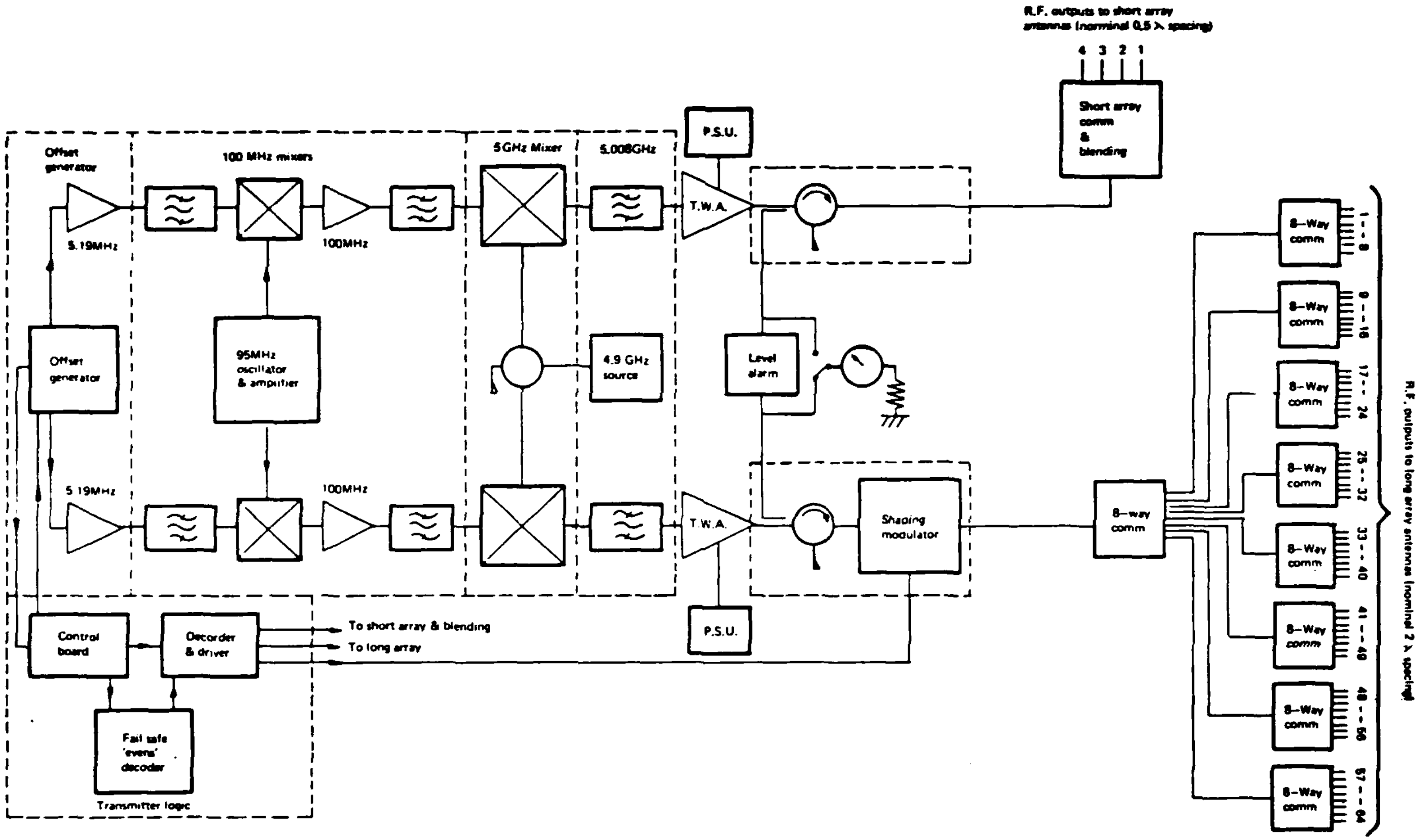


Fig 3.6 Azimuth transmitter block diagram

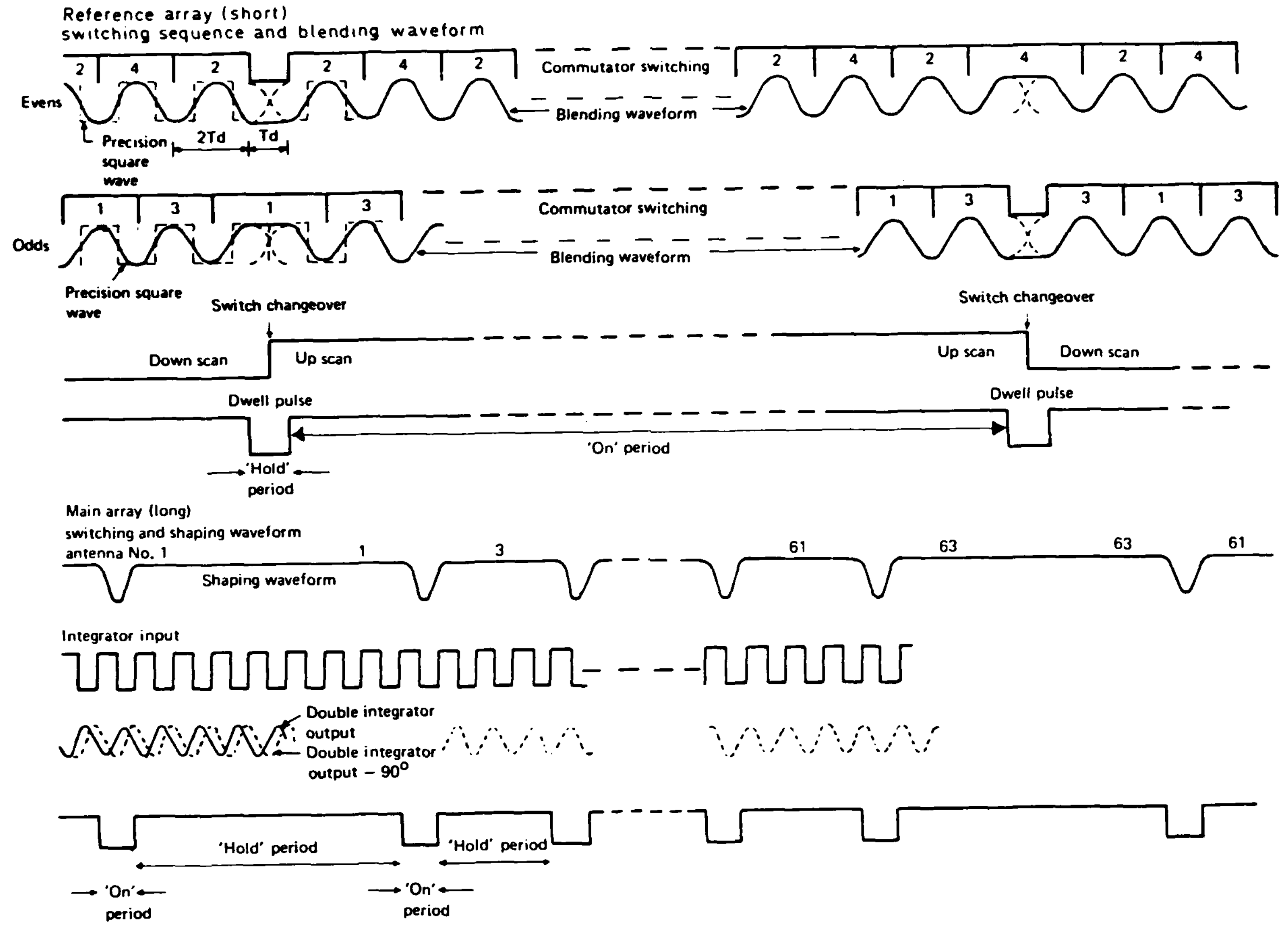


Fig 3.7 Azimuth facilities blending and shaping

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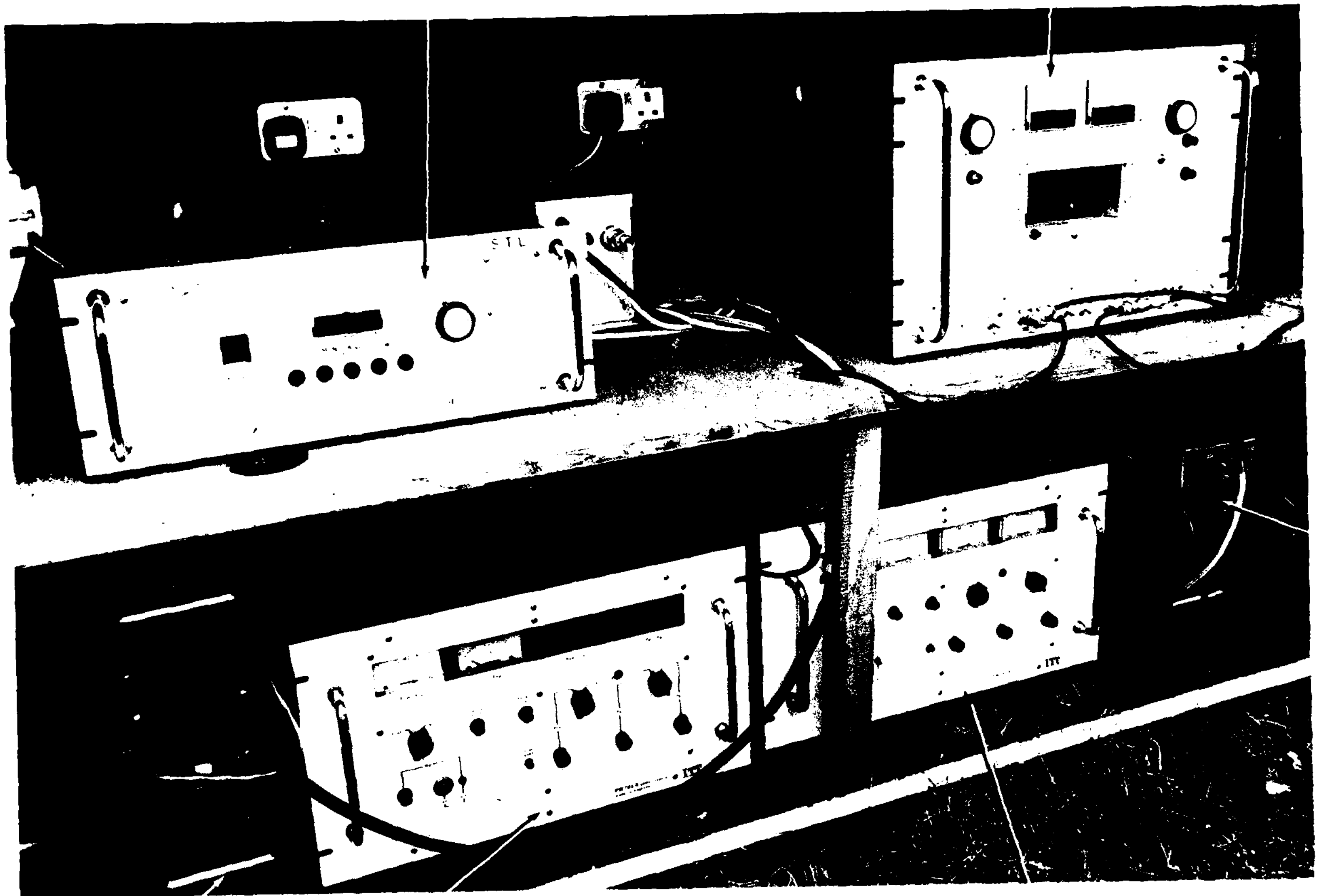


Fig 3.8 Azimuth transmitter

Fig 3.9

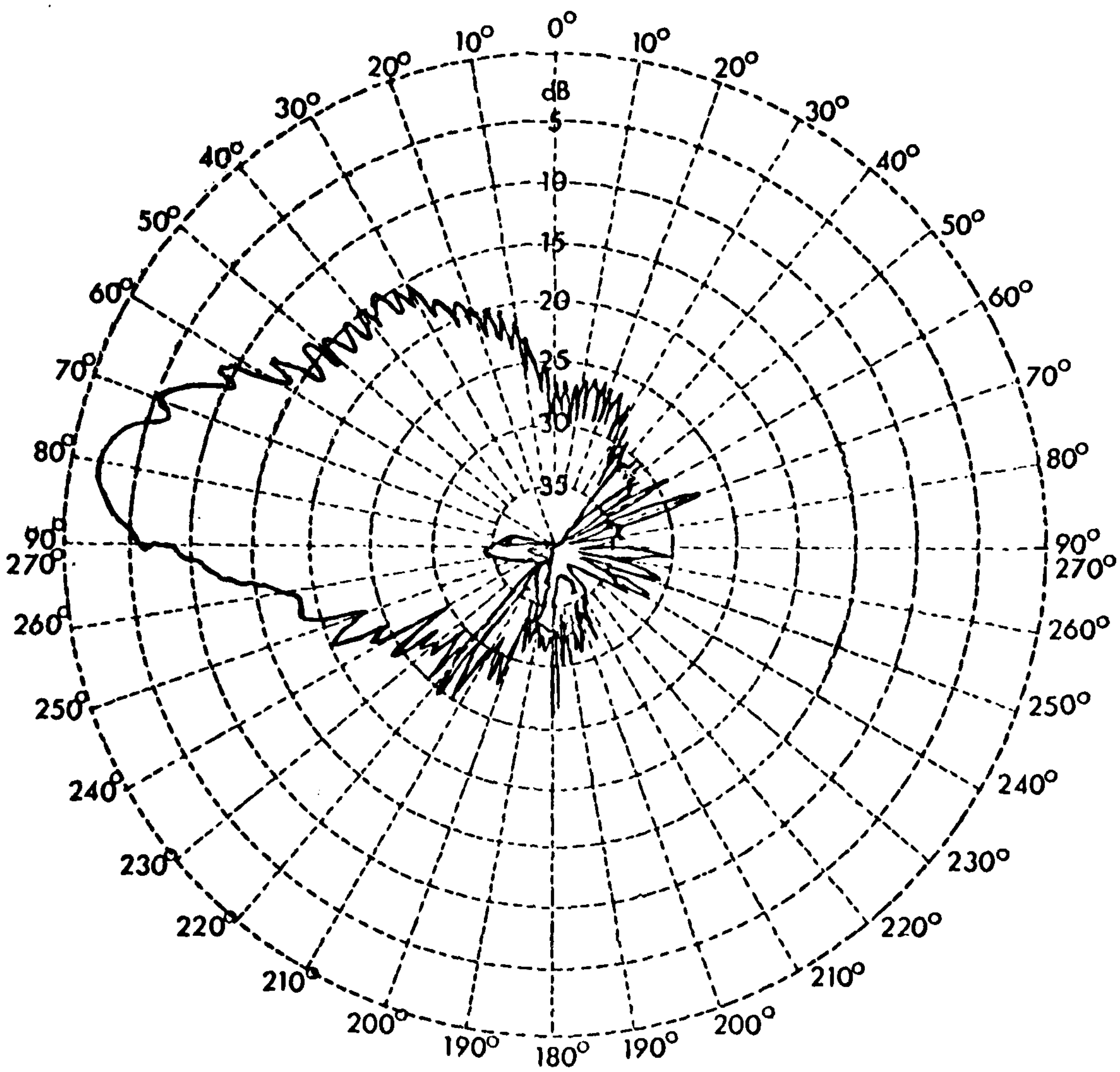


Fig 3.9 Monopole on 3 ft counterpoise (vertical pattern)

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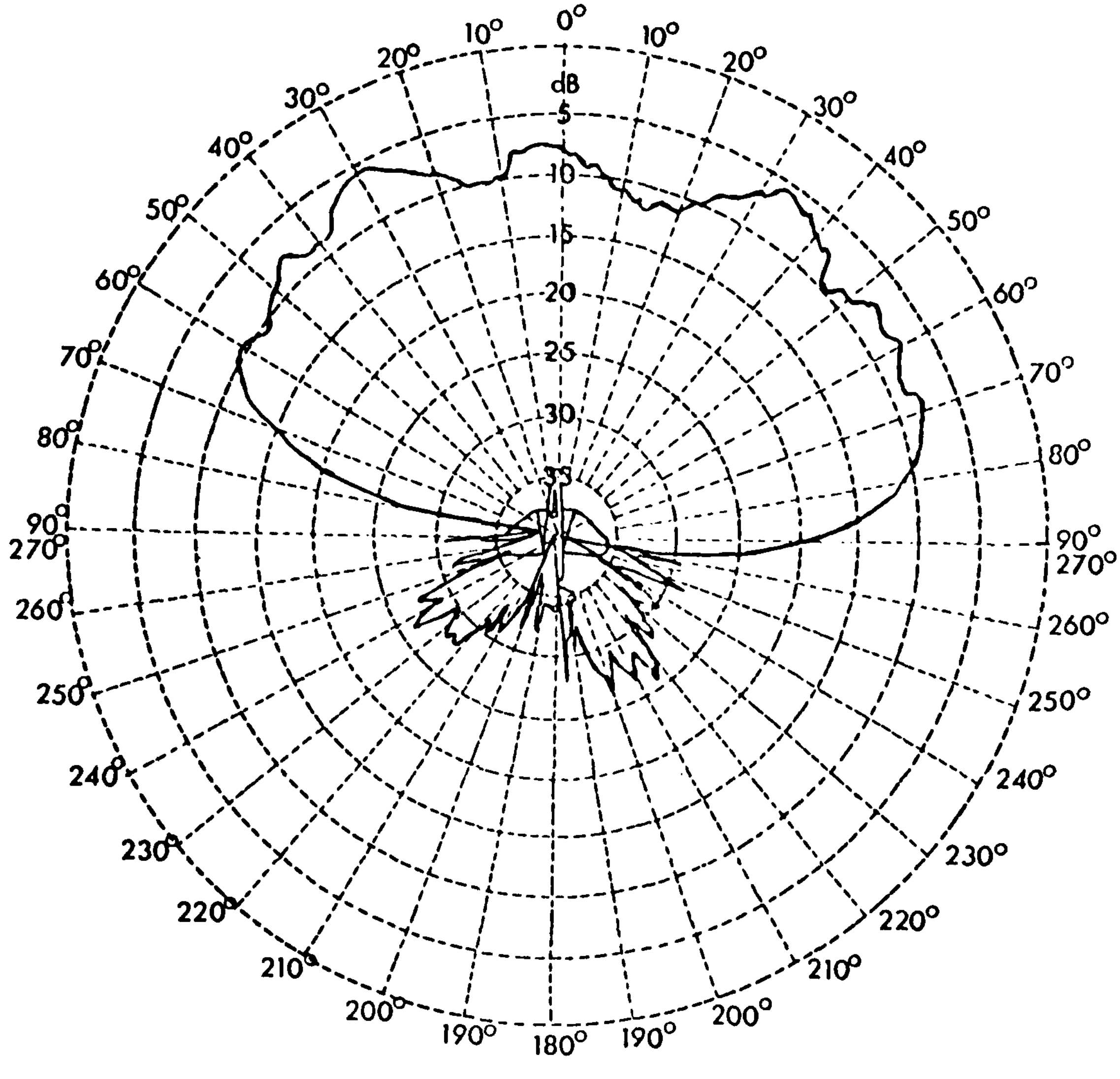


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Fig 3.10 Monopole on 3 ft counterpoise (horizontal pattern)

Fig 3.11

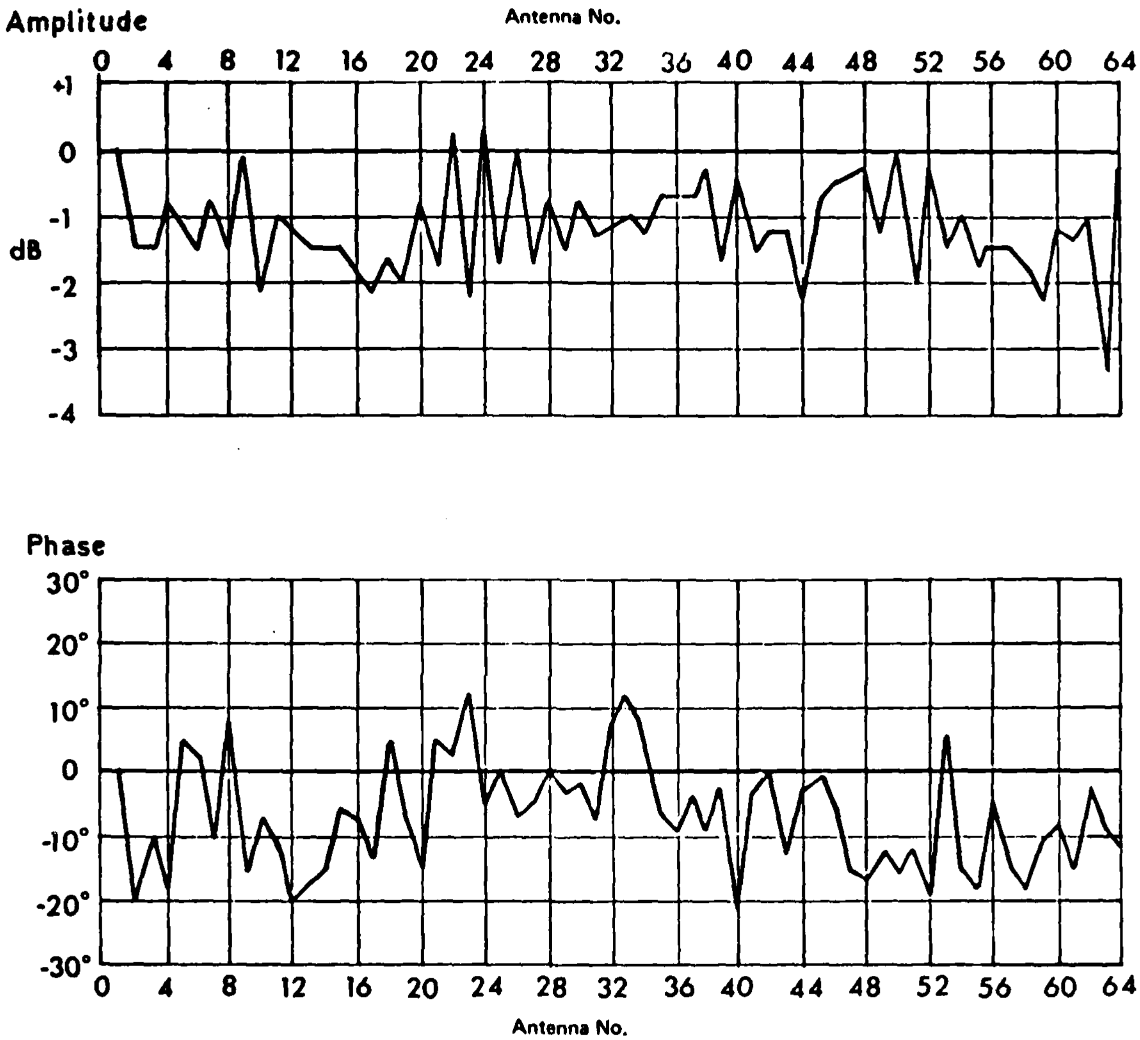


Fig 3.11 Transmitted signal phase and amplitude spread (approach azimuth)

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Fig 3.12 Missed approach azimuth

Fig 3.13

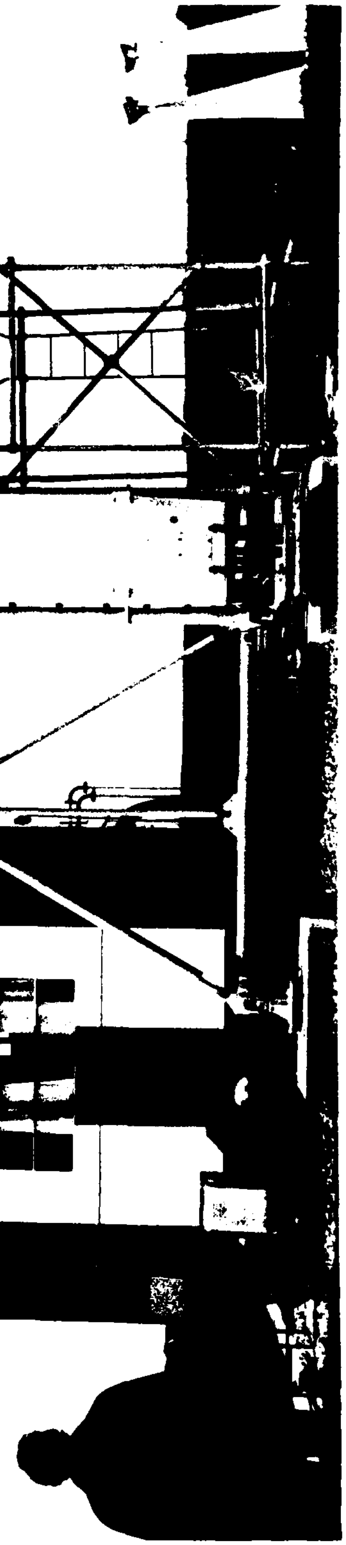

Fig 3.13 90 wavelength elevation array

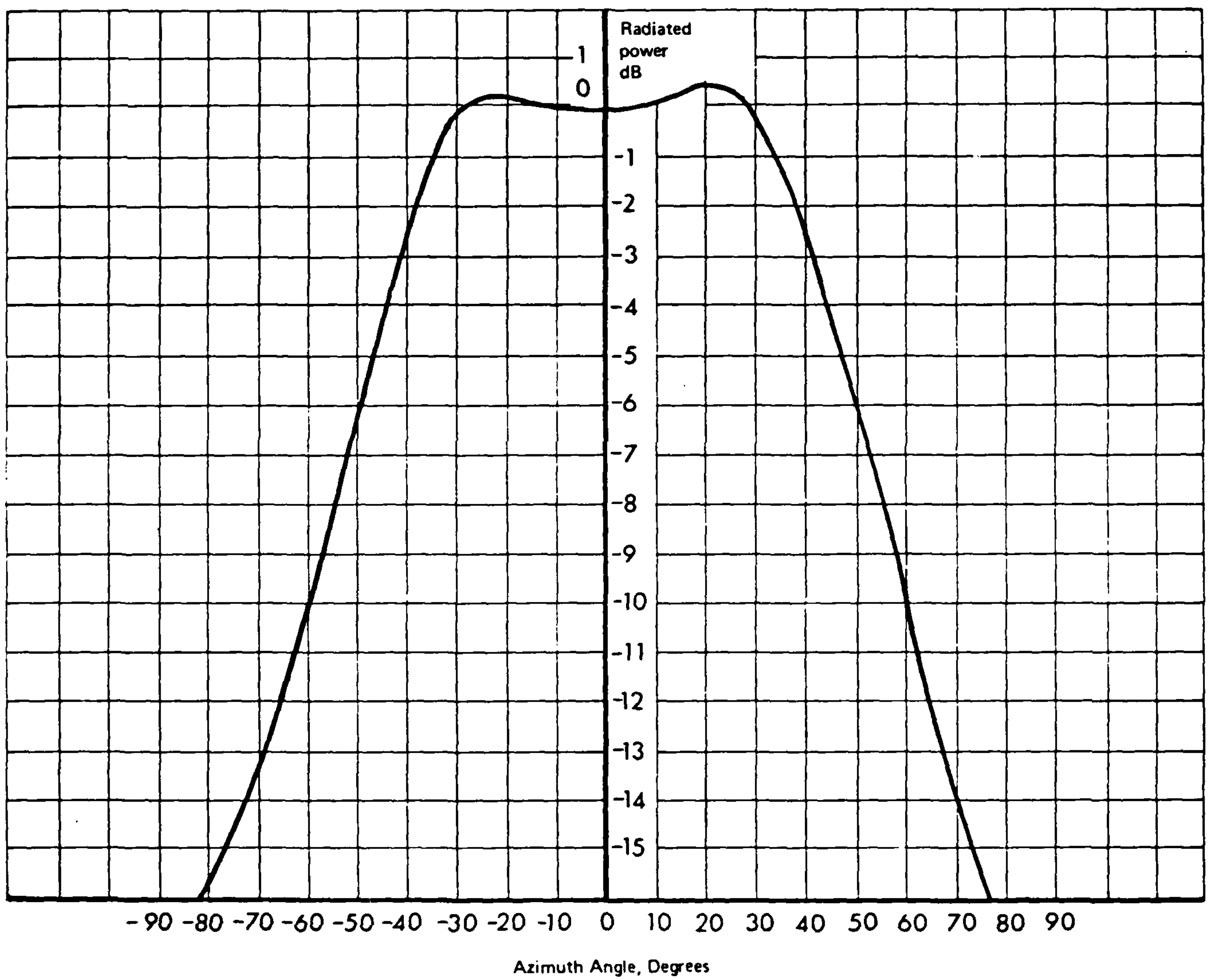


**Fig 3.14 Array element azimuth radiation pattern**

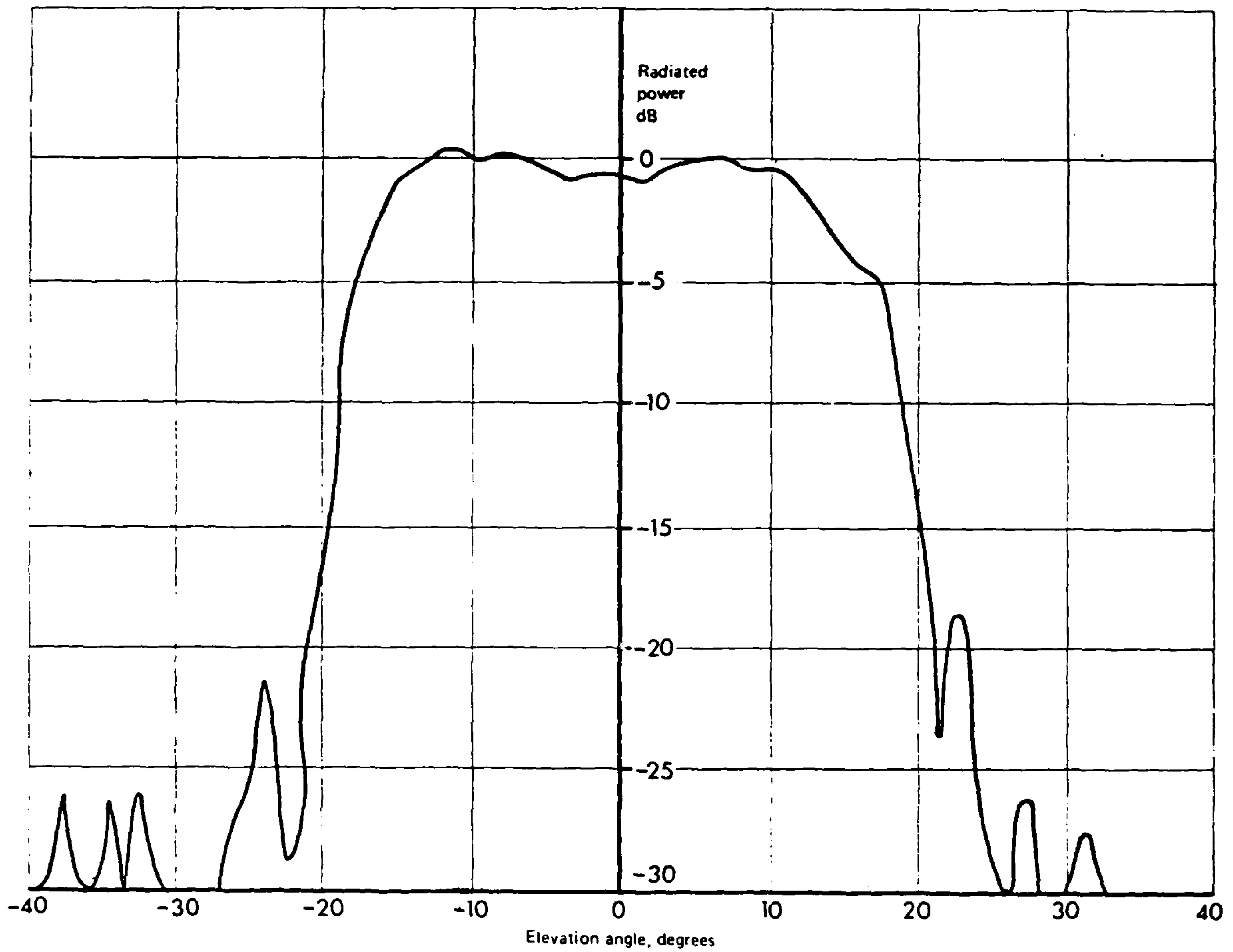


Fig 3.15 Array element elevation radiation pattern

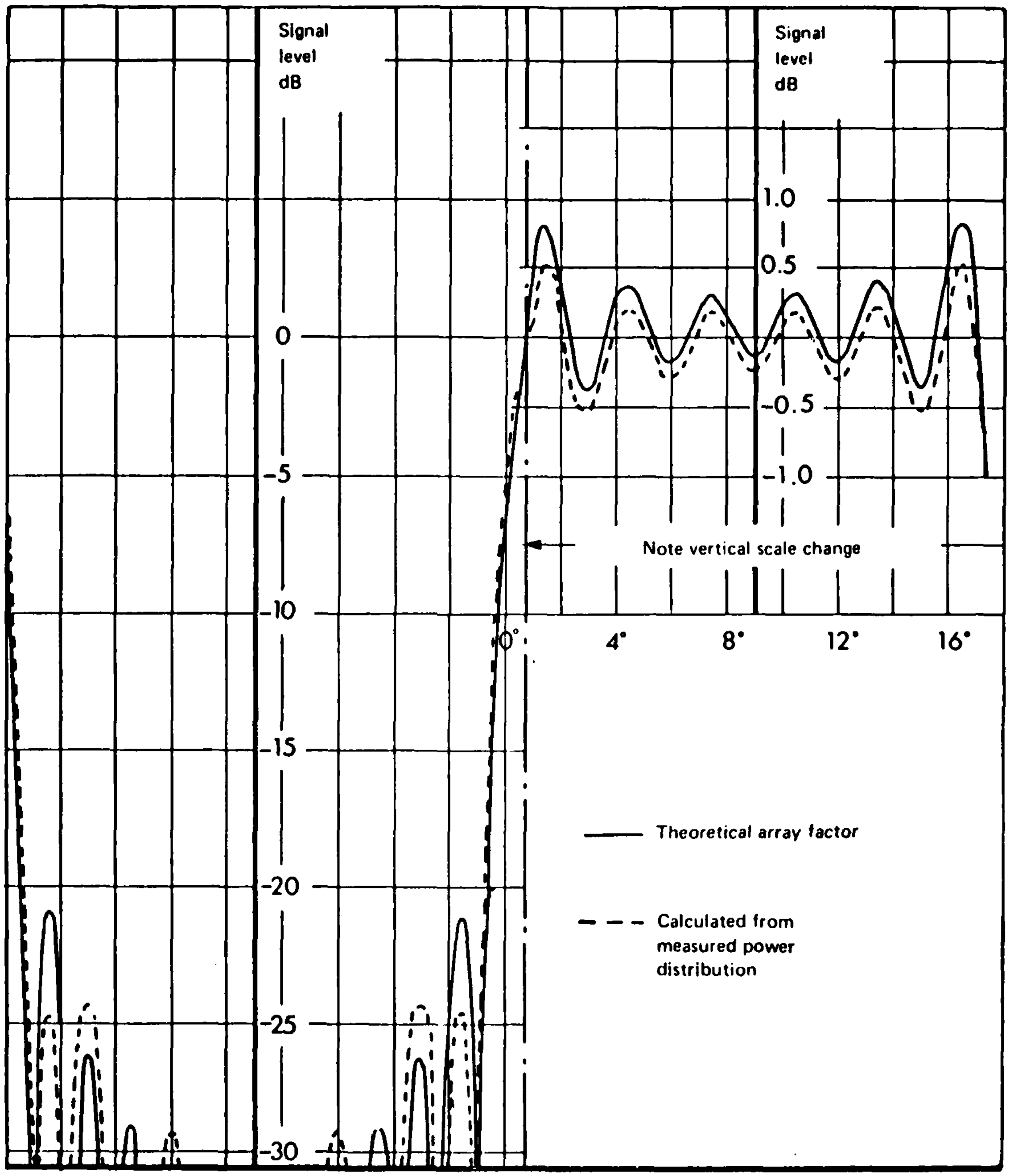


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Fig 3.16 Reference antenna array factors

Fig 3.17

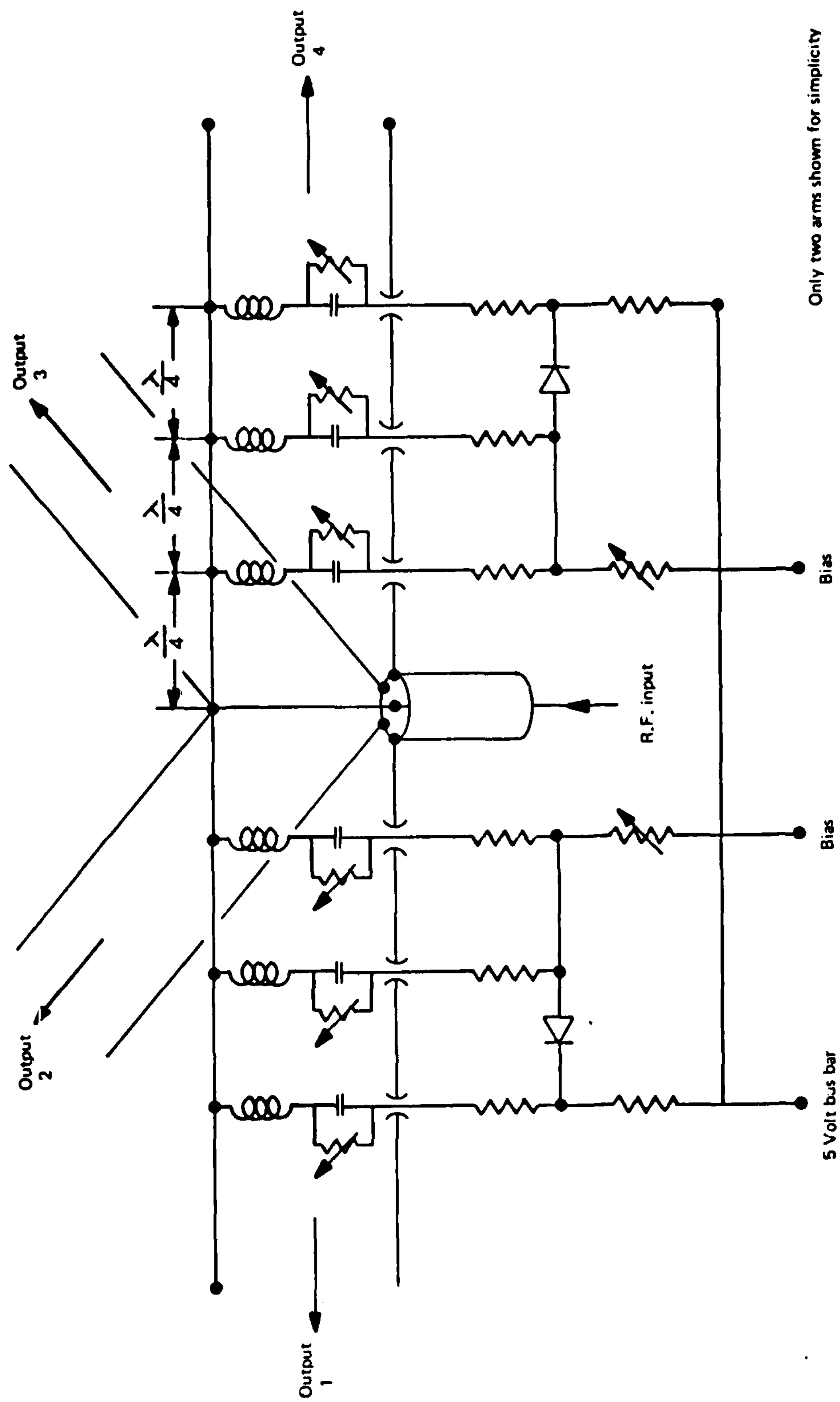


Fig 3.17 Resonant switch and biassing circuit

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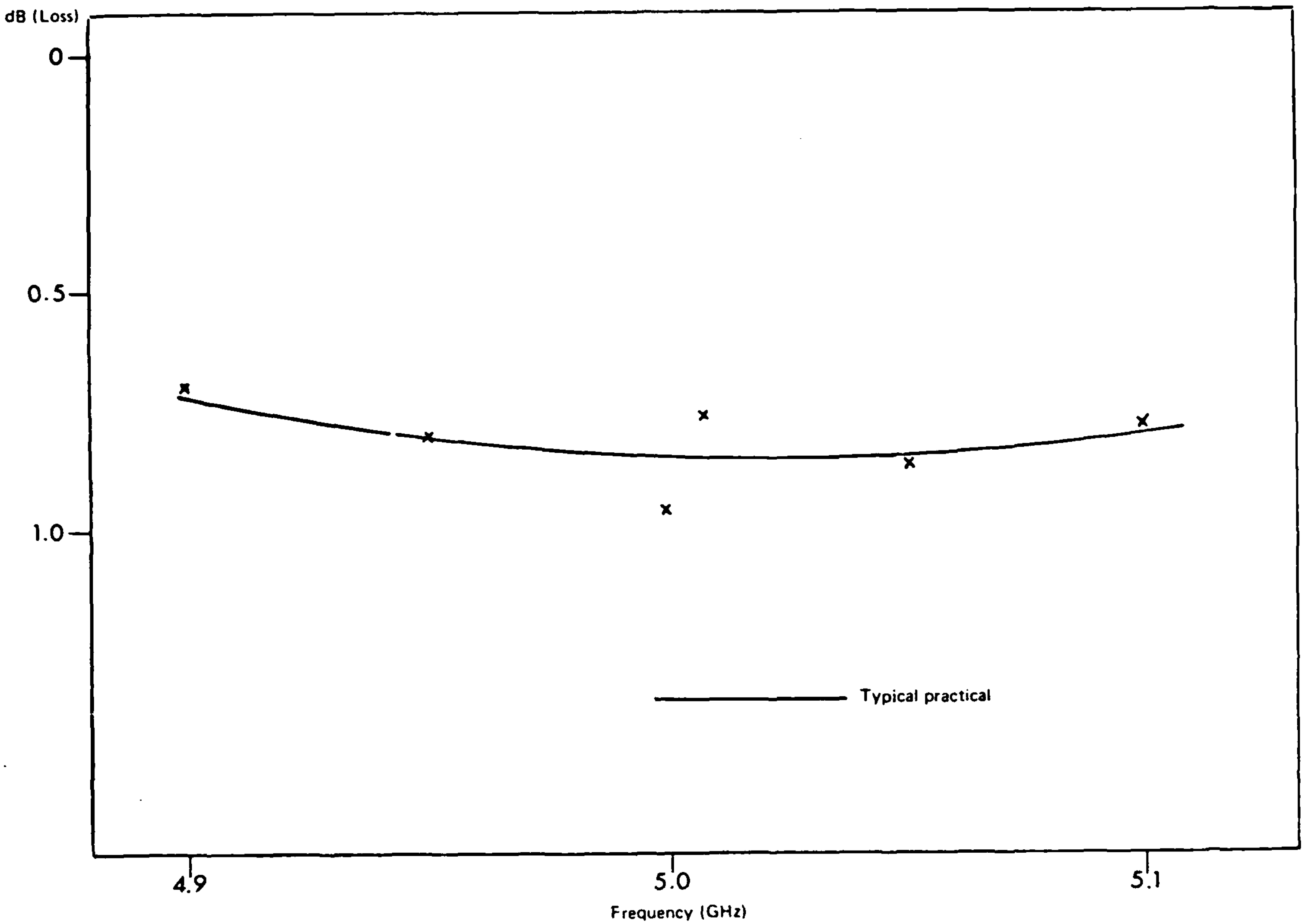


Fig 3.18 Curve of insertion loss for 4-way switching module

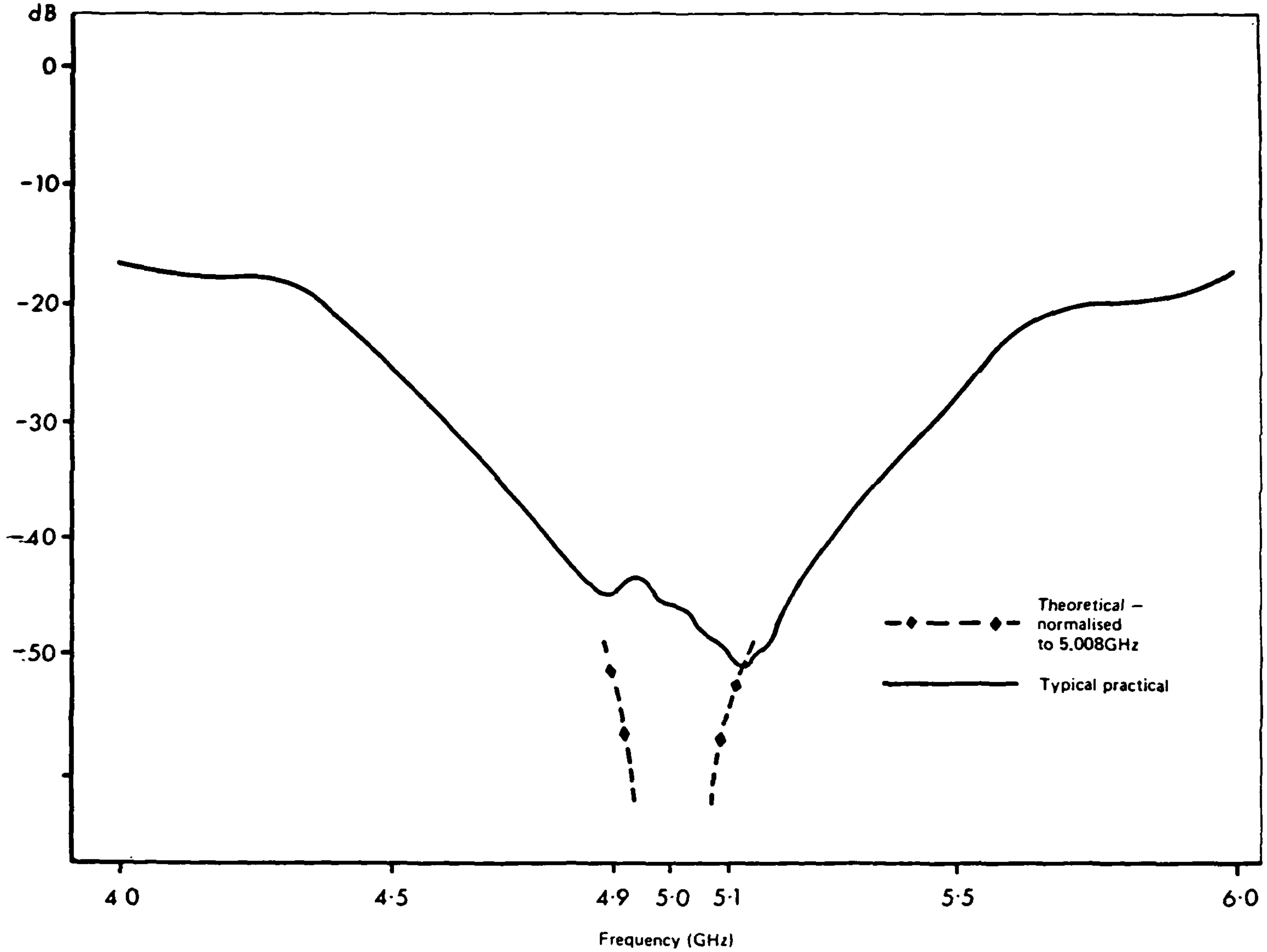


Fig 3.19 Theoretical and practical curves of isolation for 4-way switching module

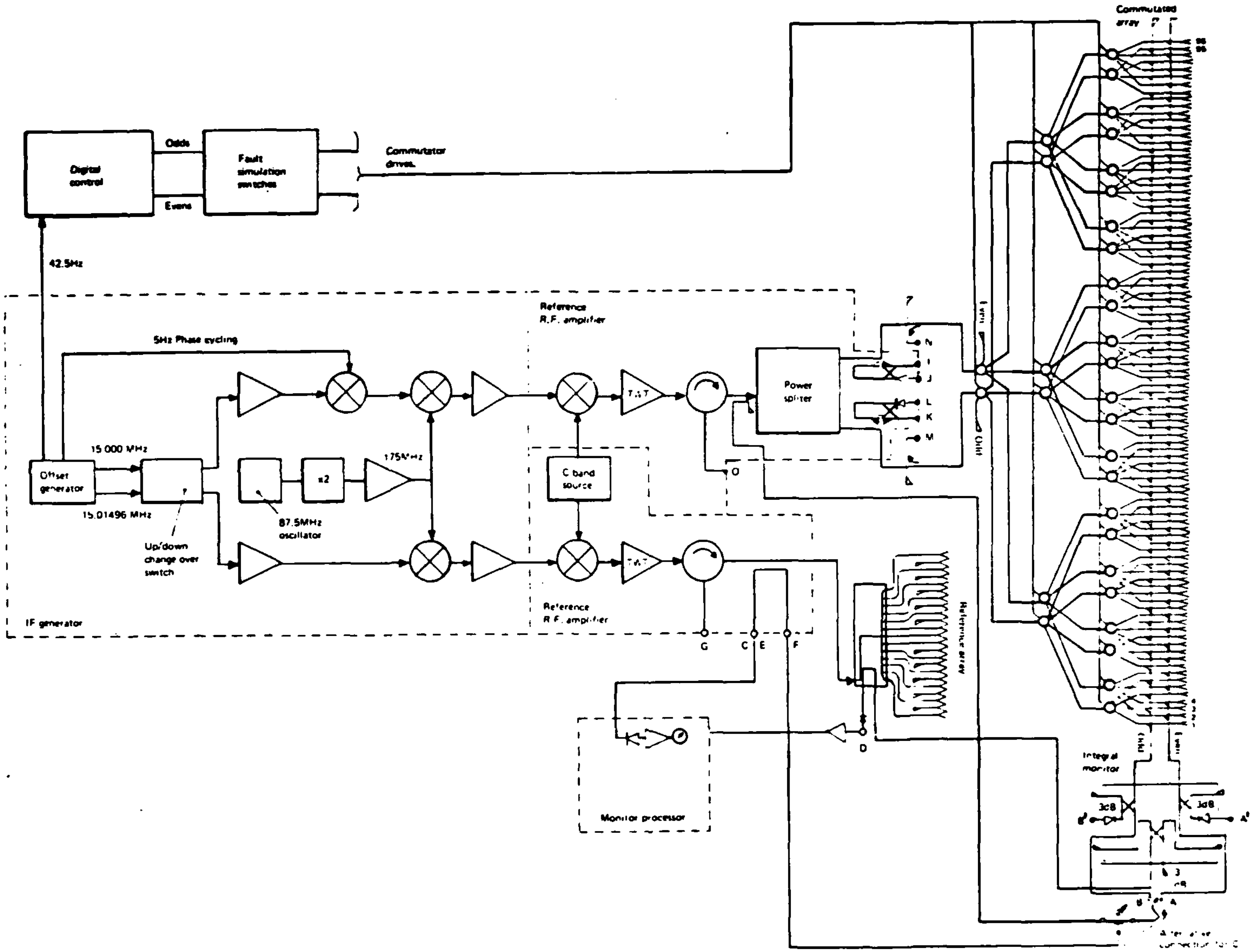


Fig 3.20 Elevation ground system

Fig 3.21

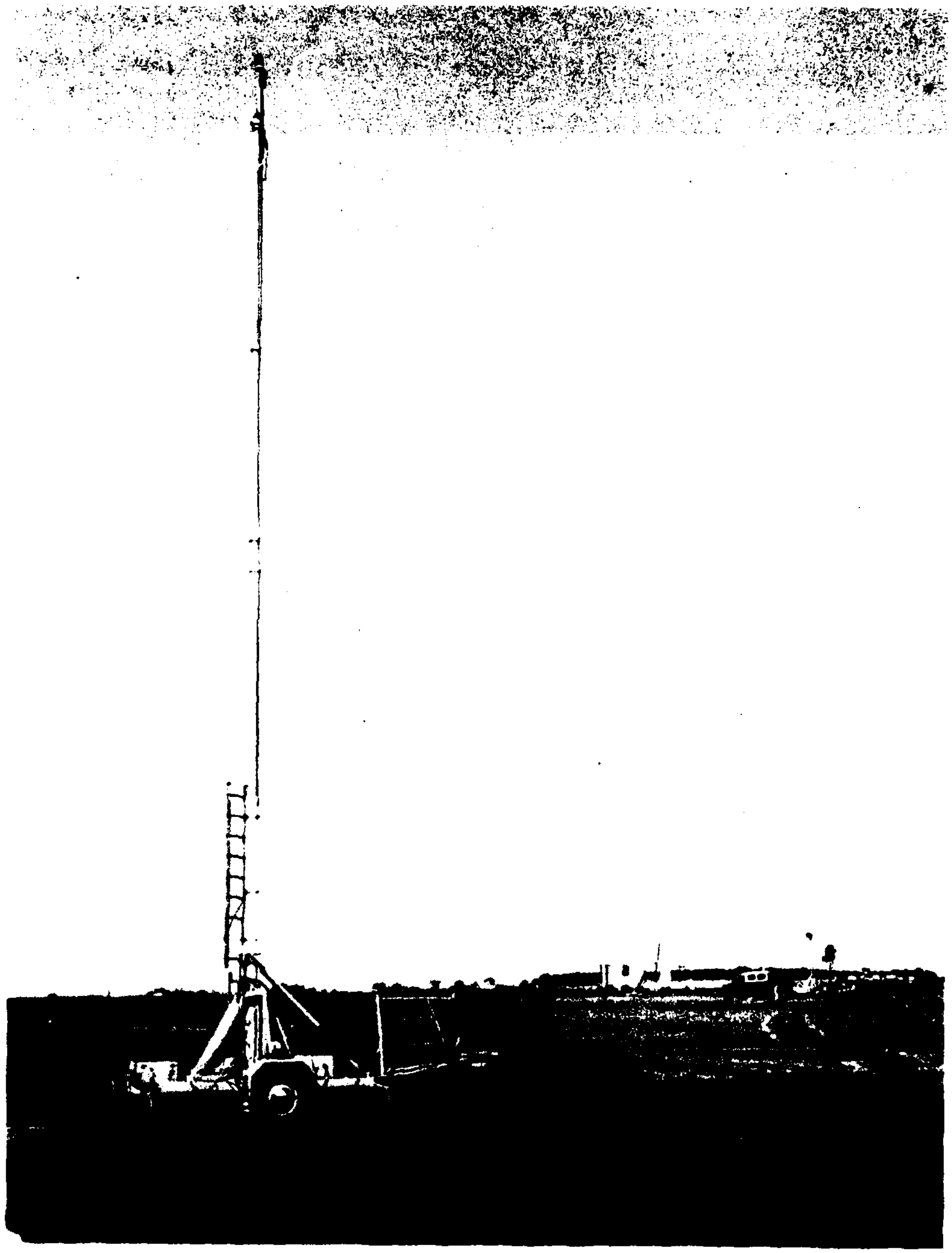

Fig 3.21 Elevation field monitor mounting

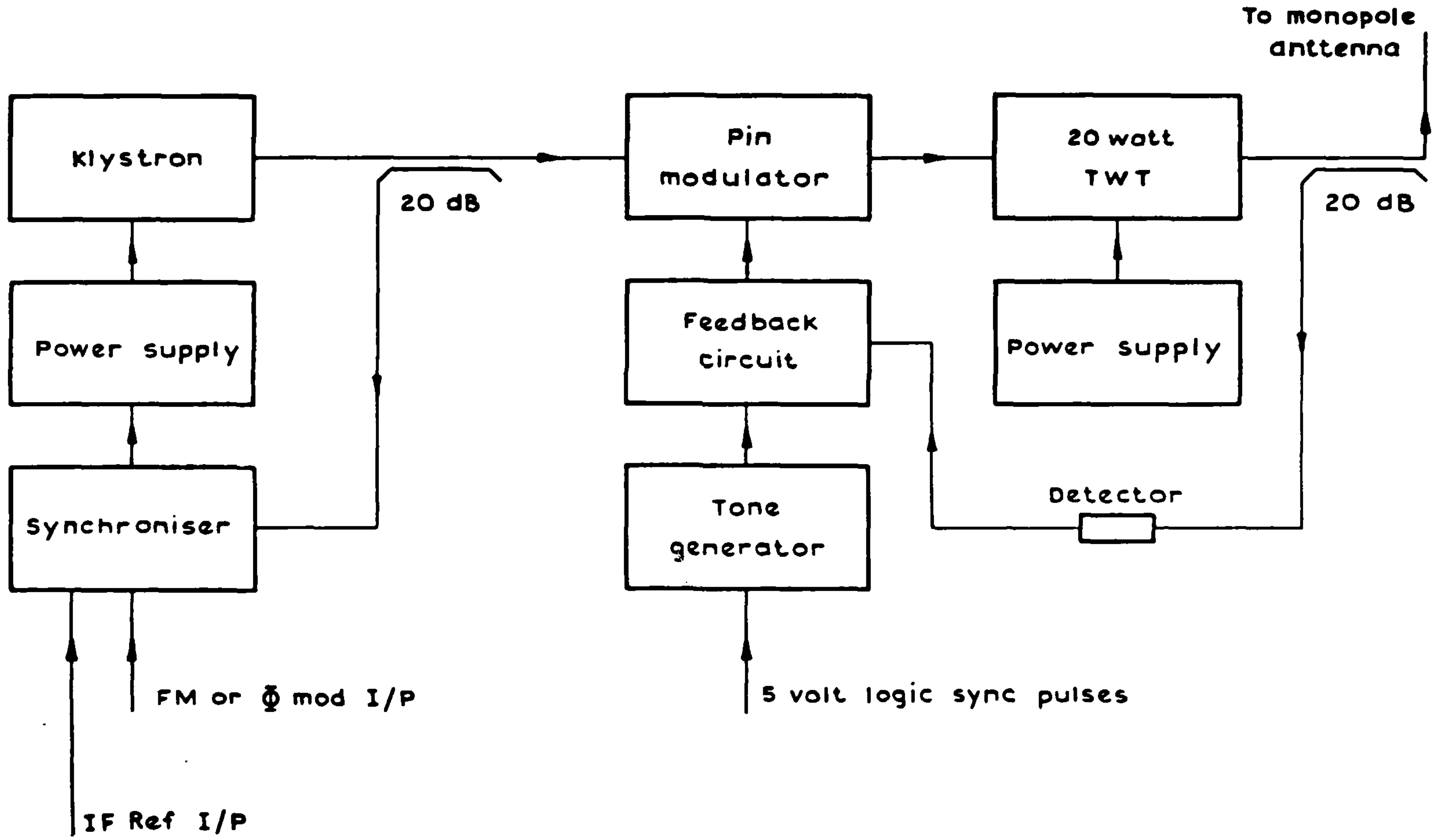


Fig 3.22 Data transmitter block diagram

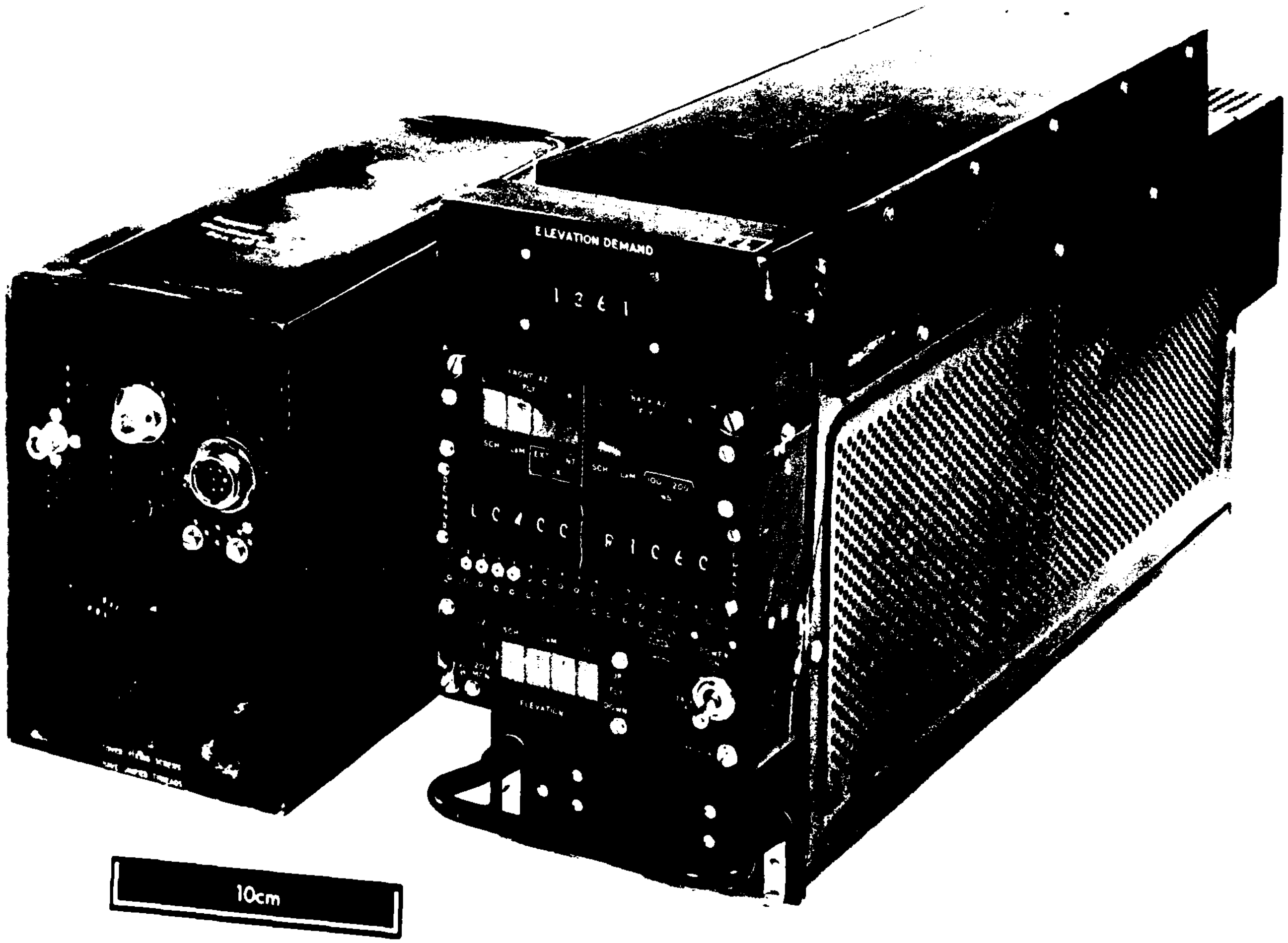


Fig 3.23 S type receiver system

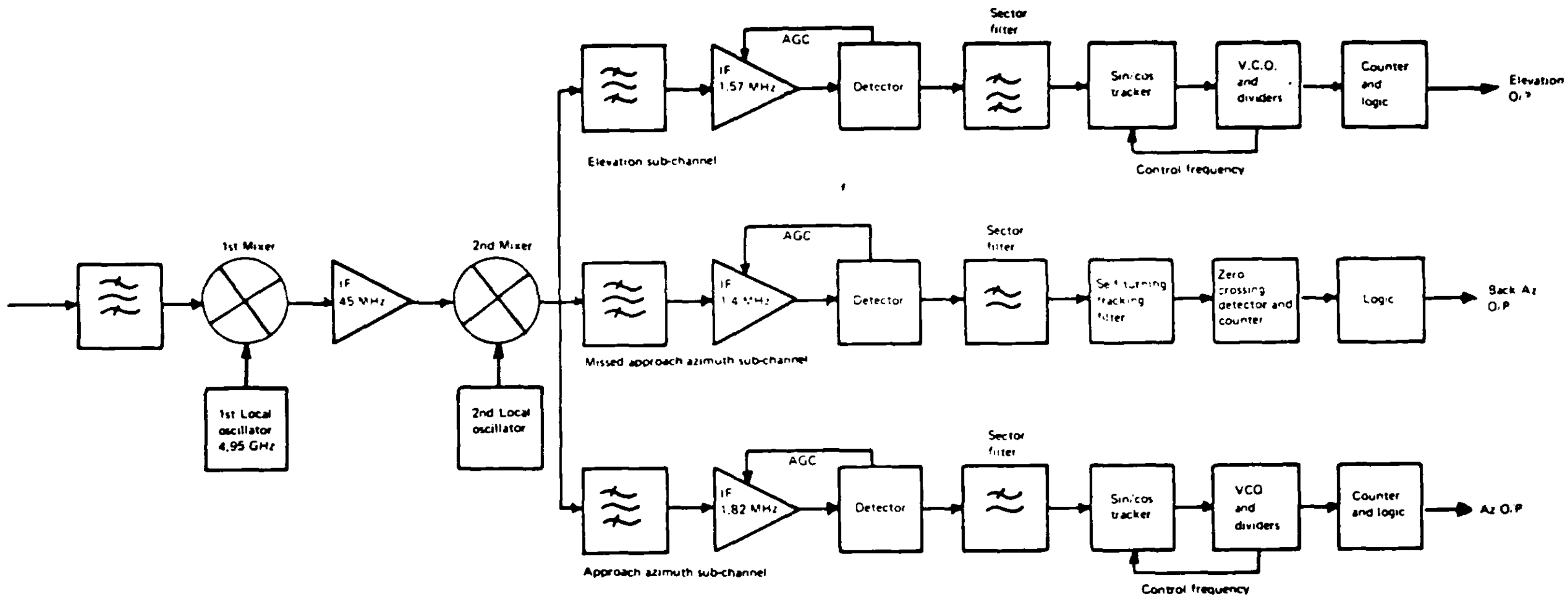


Fig 3.24 Outline block diagram of type S receiver

Fig 3.25

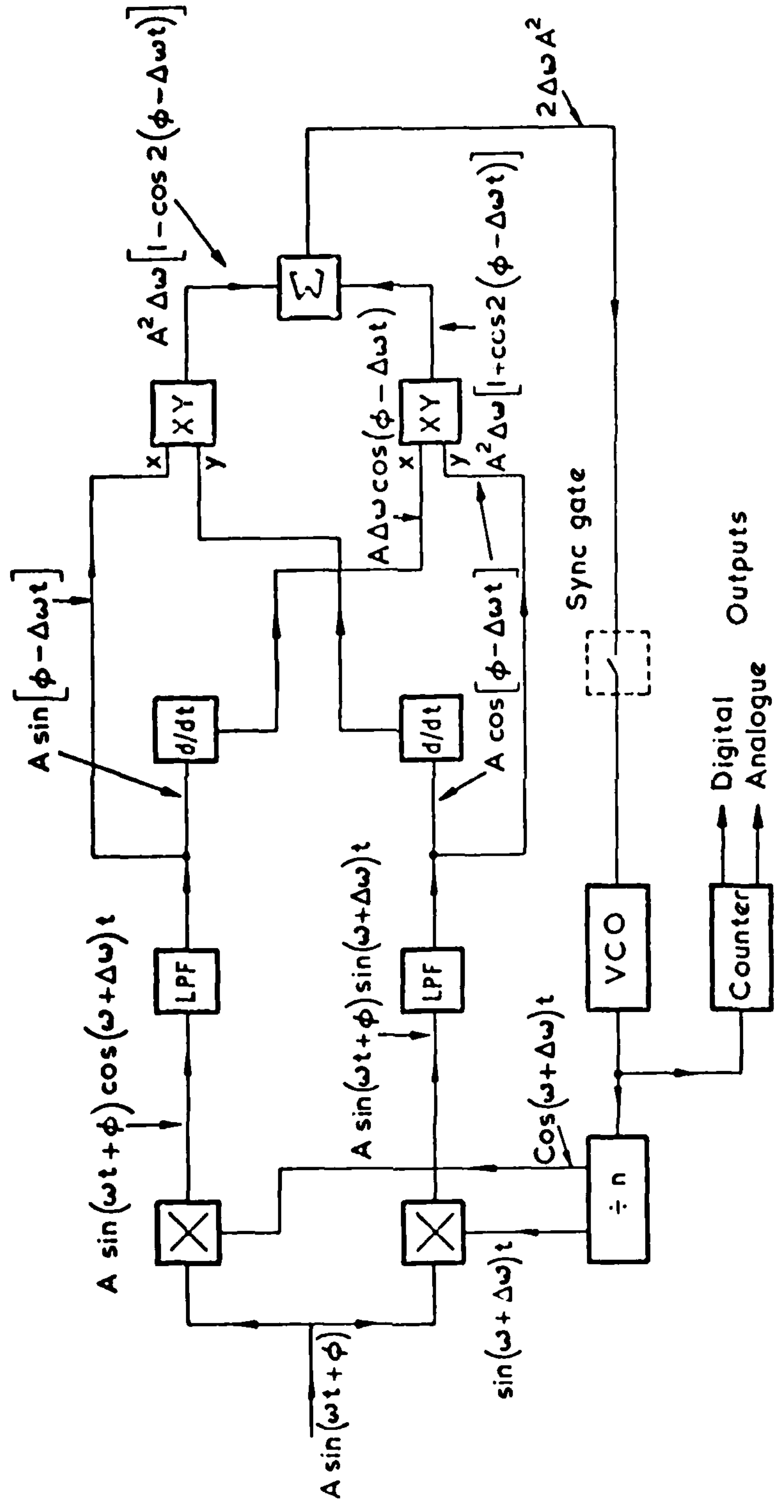


Fig 3.25 Sine/cosine tracker system detail diagram

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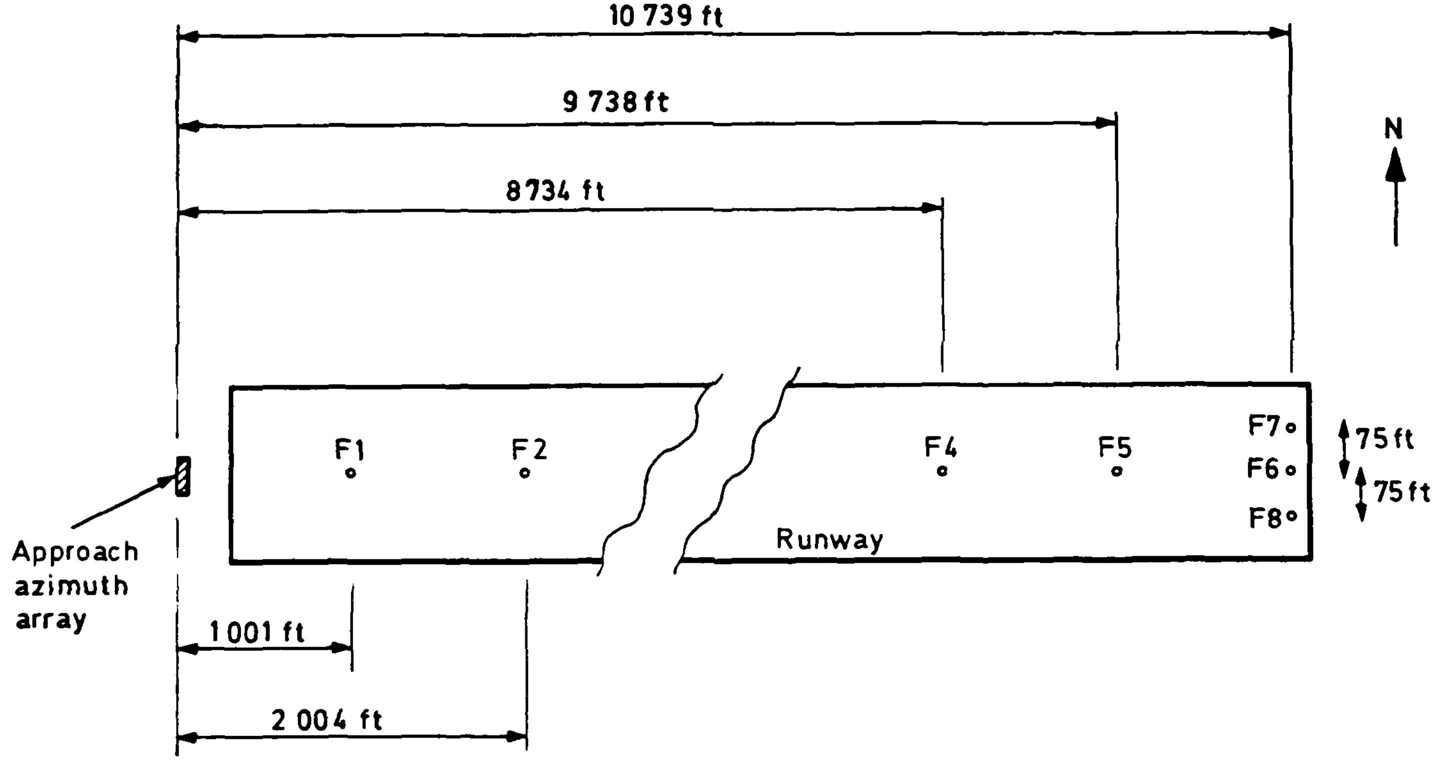


Fig 4.1a Close and long range approach azimuth test points

Fig 4.1b

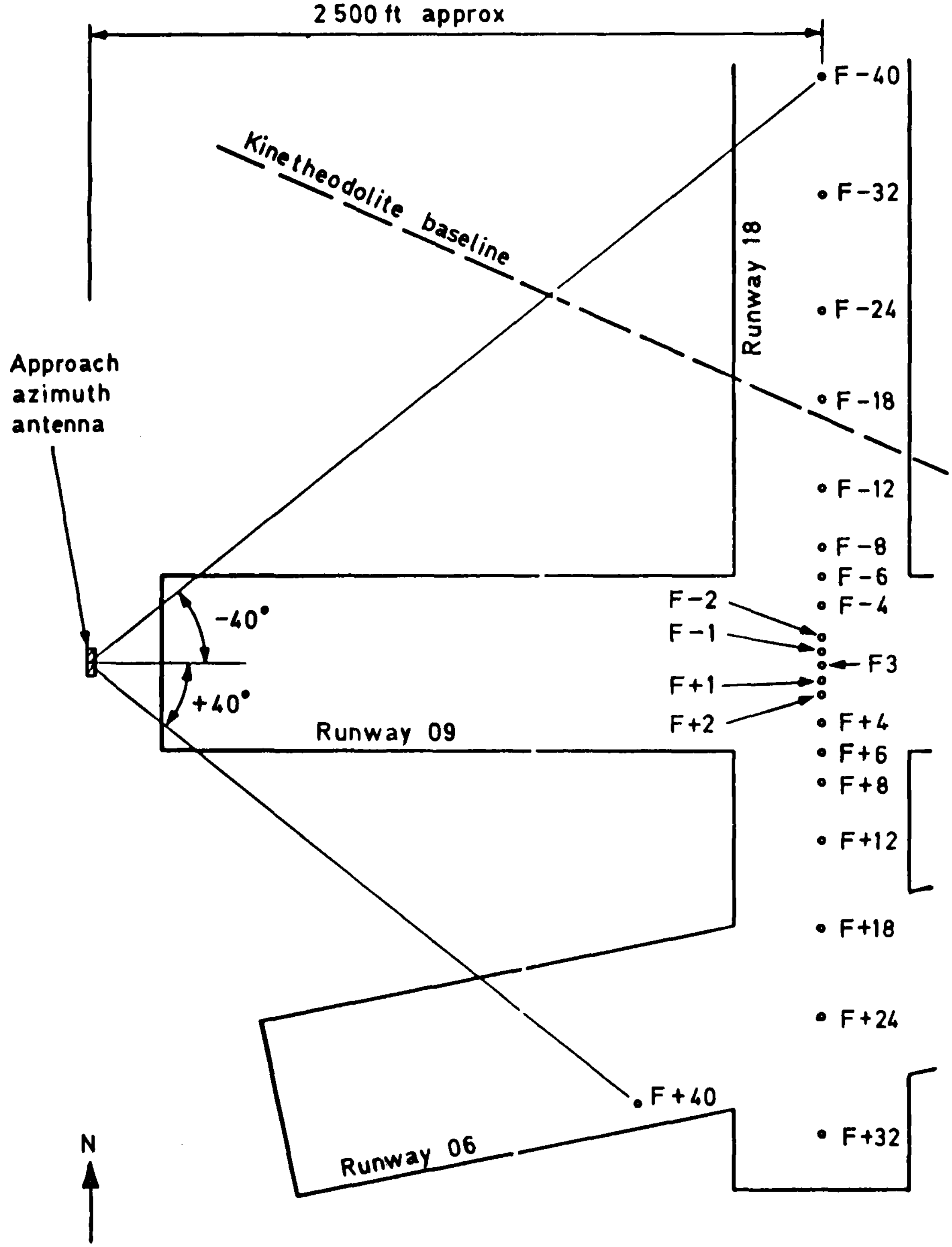


Fig 4.1b Cross runway approach azimuth test points

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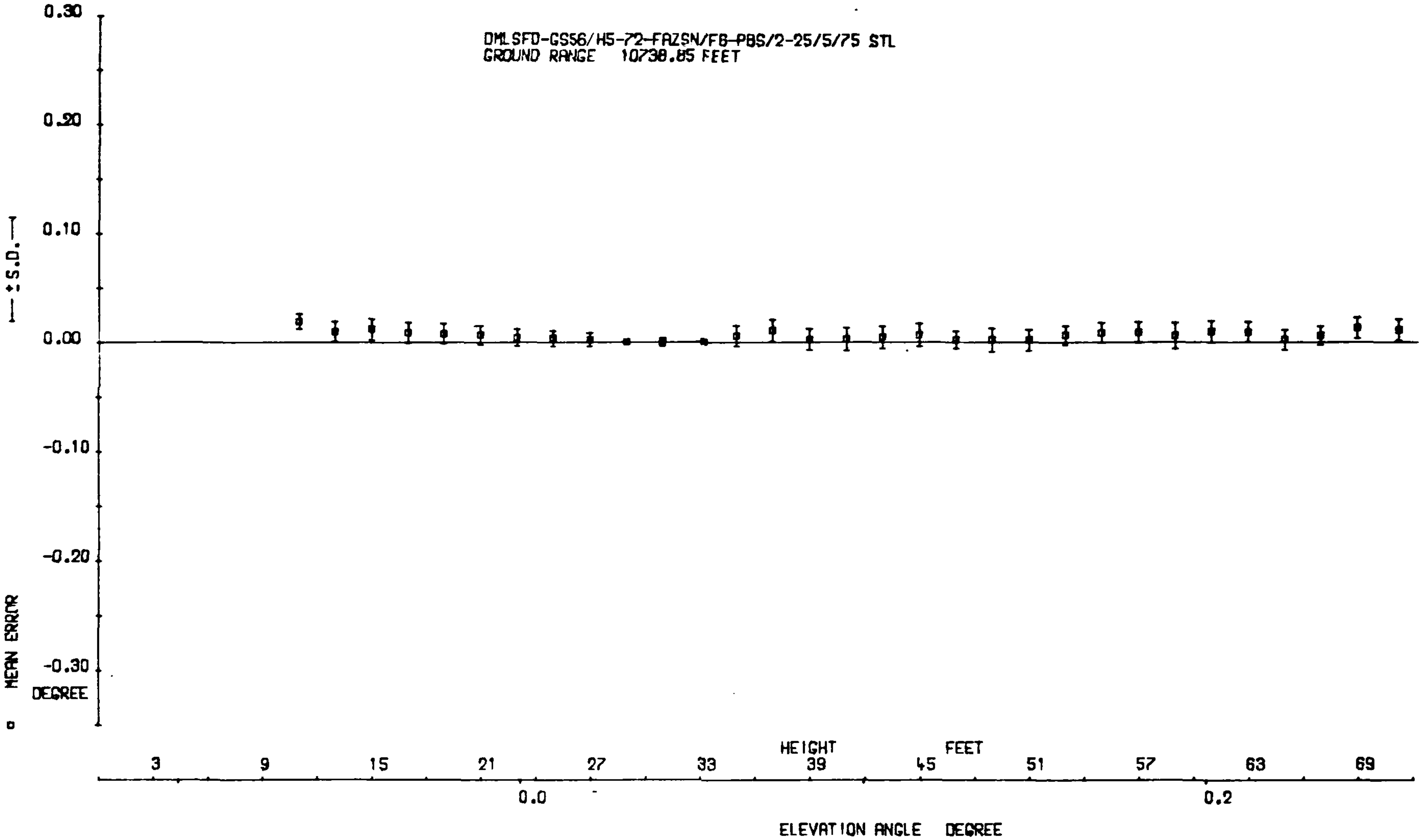


Fig 4.2 Approach azimuth static test GS56, position F6

Fig 4.2

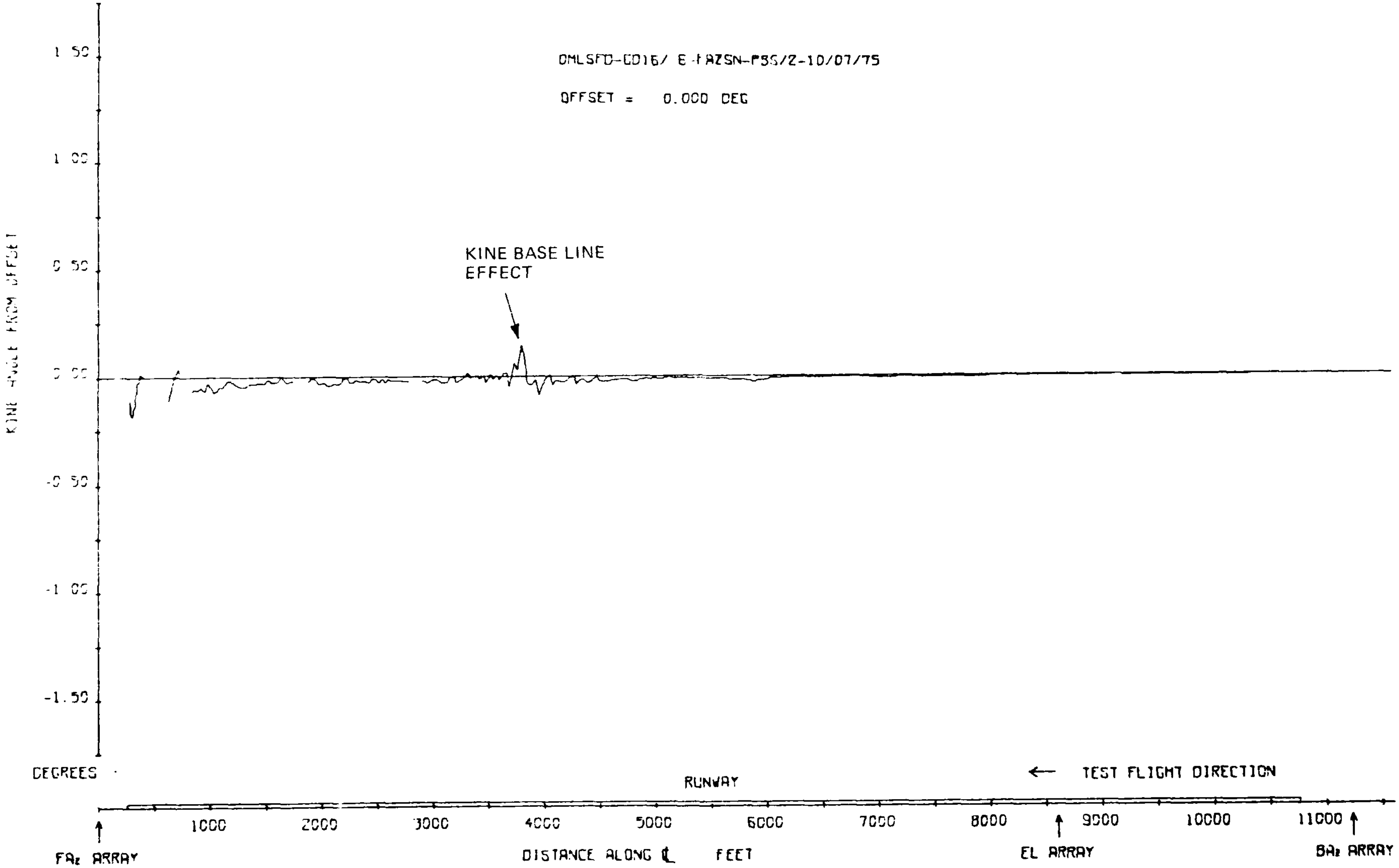


**Fig 4.3a** **Approach azimuth. Vehicle run along test runway centre line. Mast height 20 ft**

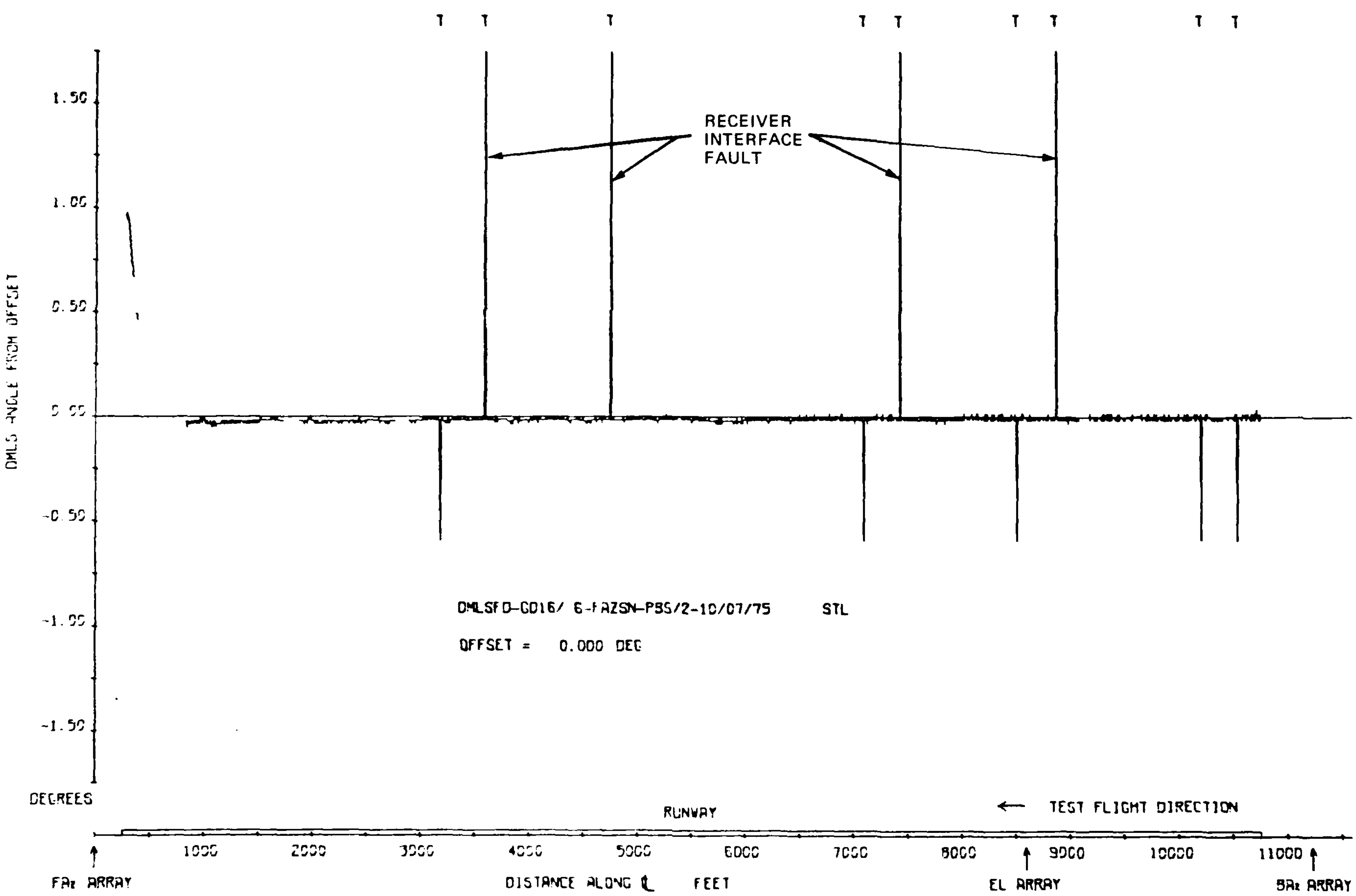


Fig 4.3b Approach azimuth. Vehicle run along test runway centre line. Mast height 20 ft

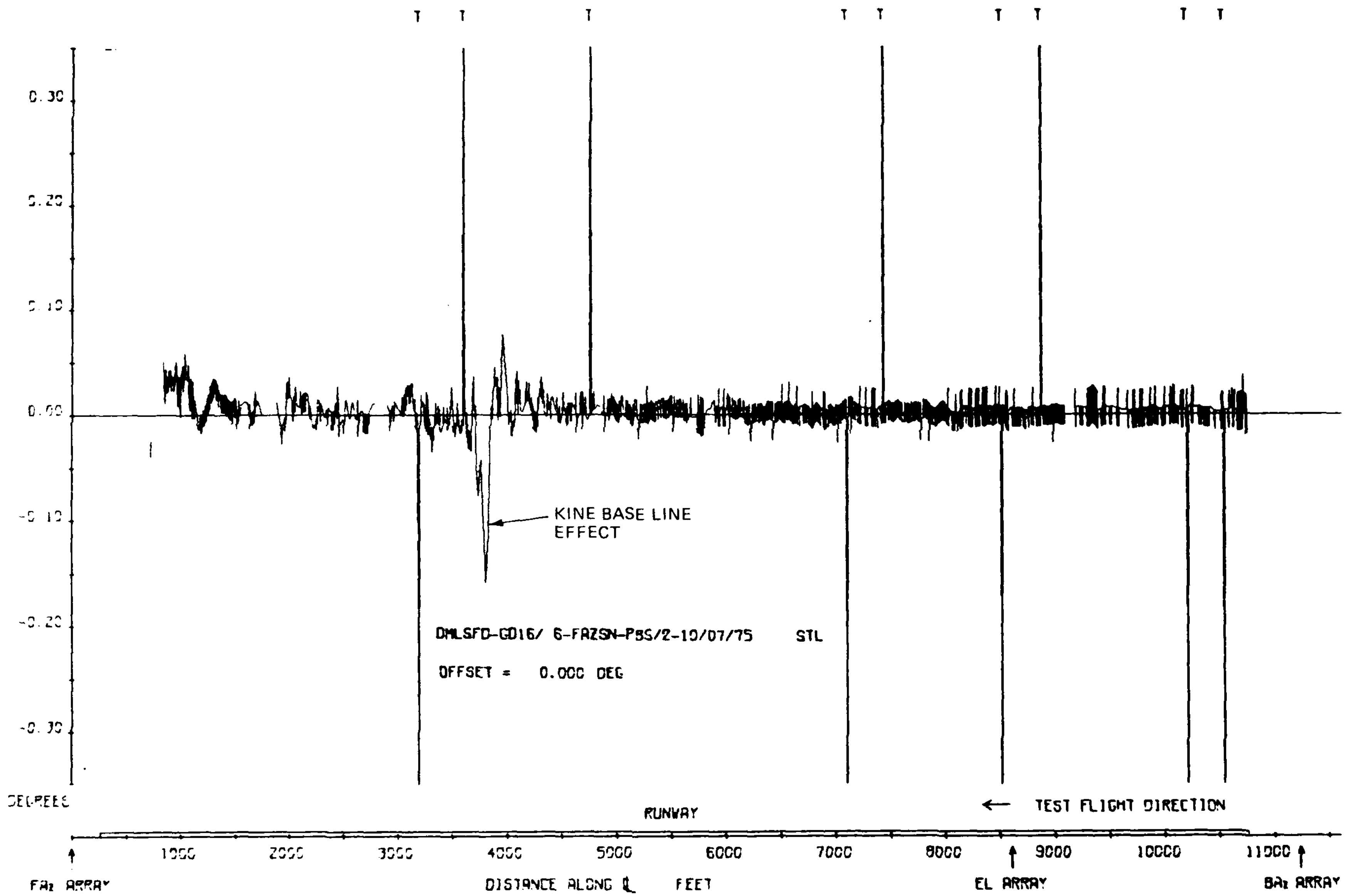


Fig 4.3c Approach azimuth. Vehicle run along test runway centre line. Mast height 20 ft

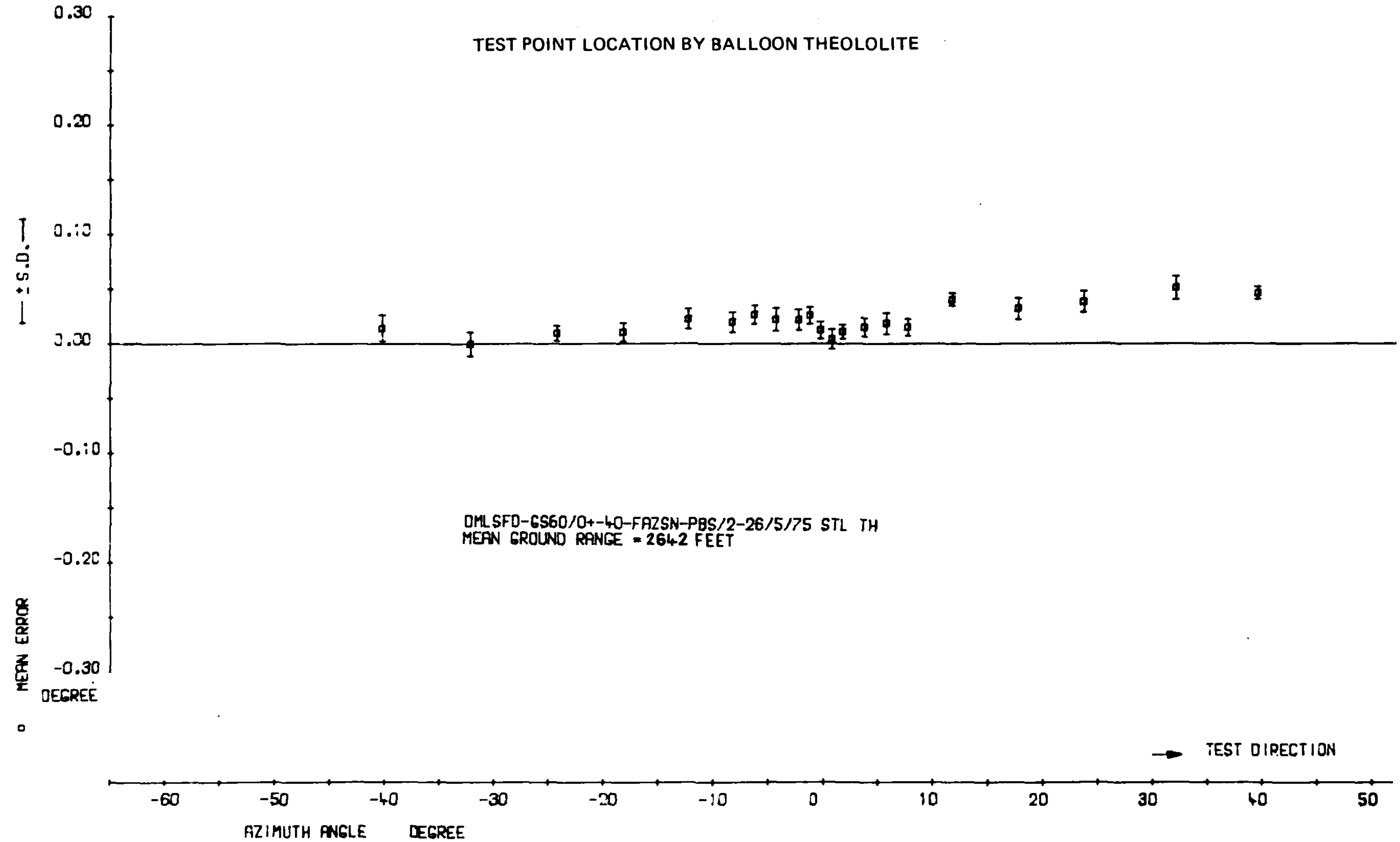


Fig 4.4 Approach azimuth cross runway test GS60

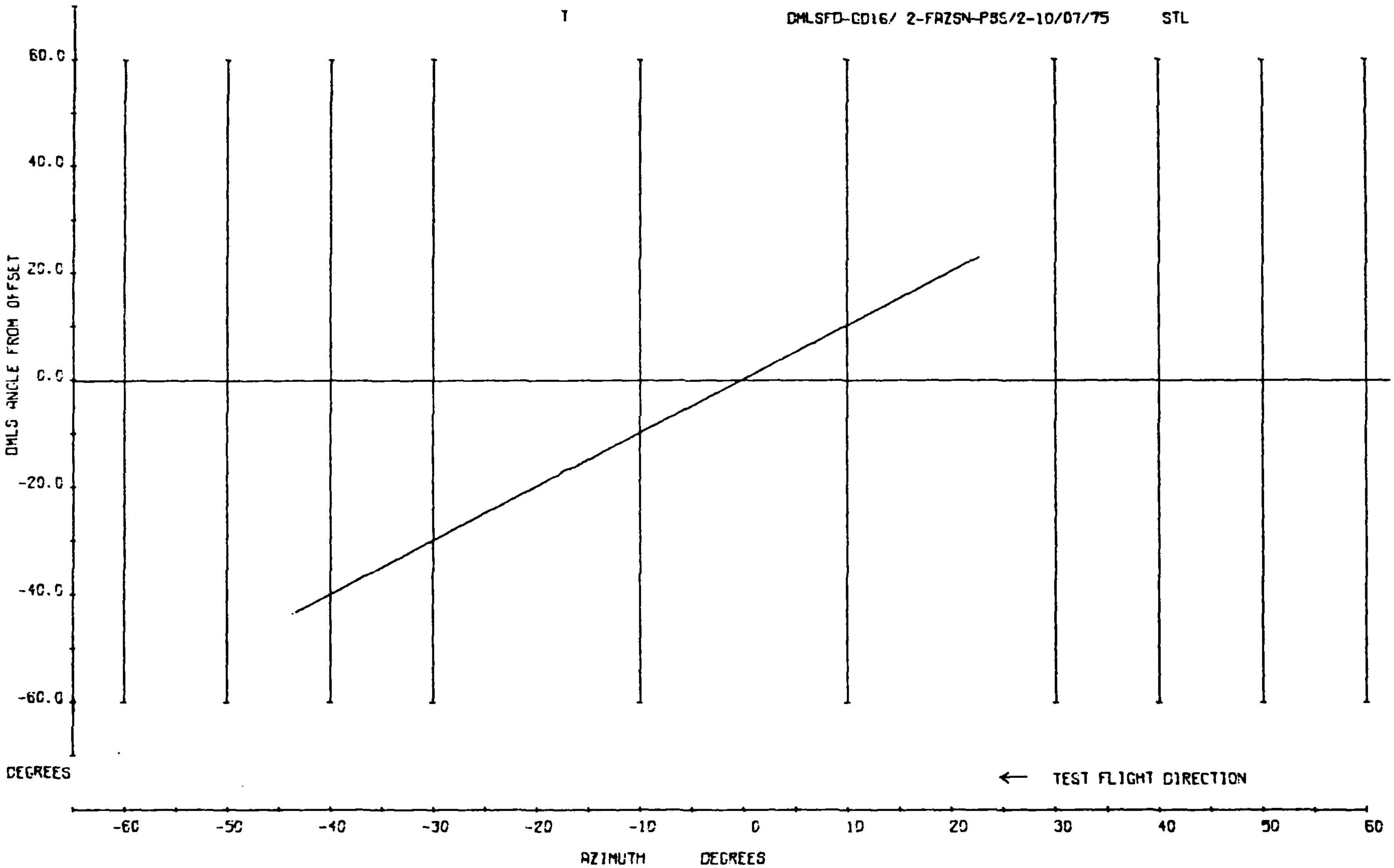


Fig 4.5a Approach azimuth. Vehicle run along N–S runway. Mast height 20 ft

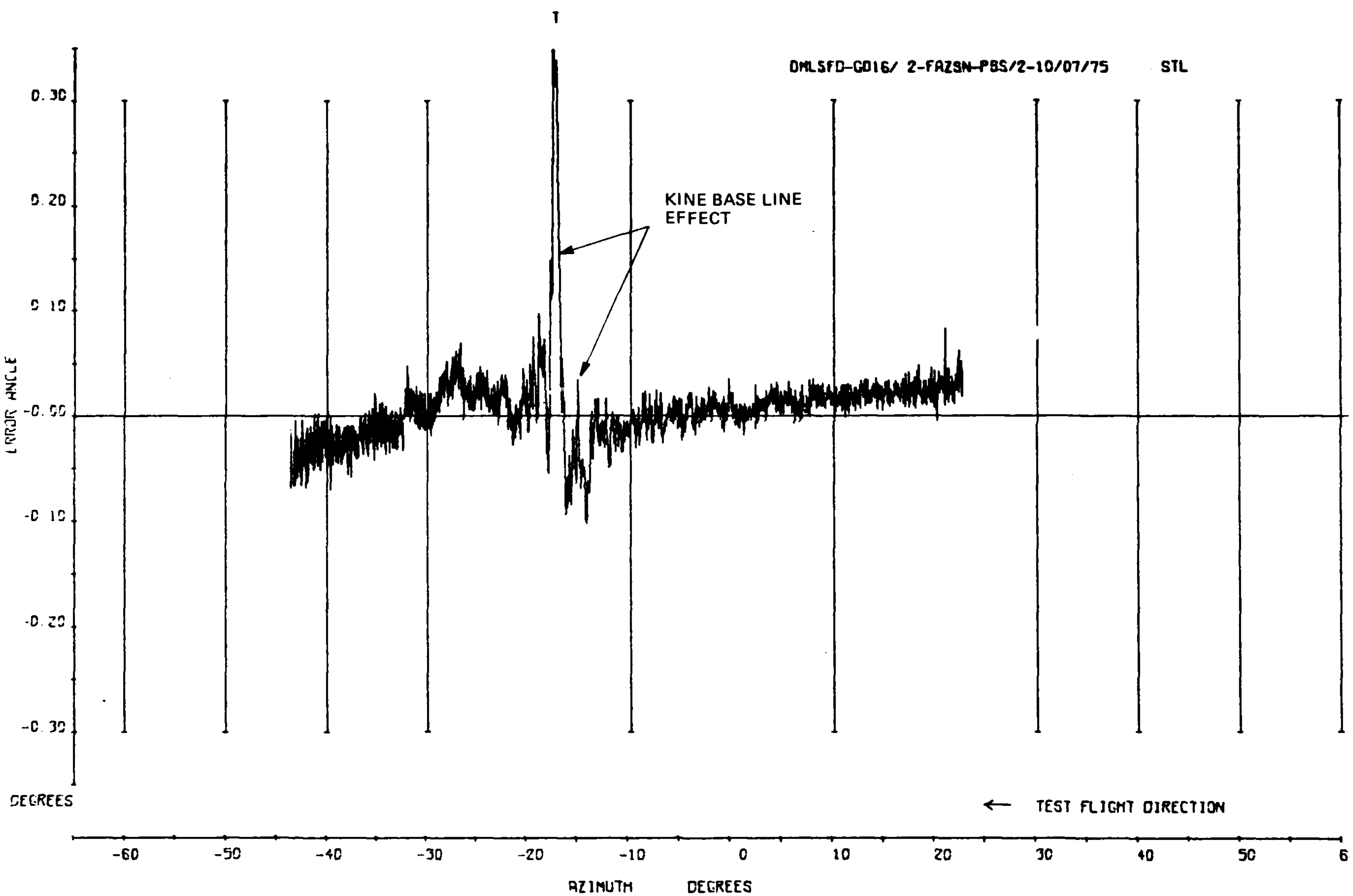


Fig 4.5b Approach azimuth. Vehicle run along N–S runway. Mast height 20 ft

Fig 4.6a

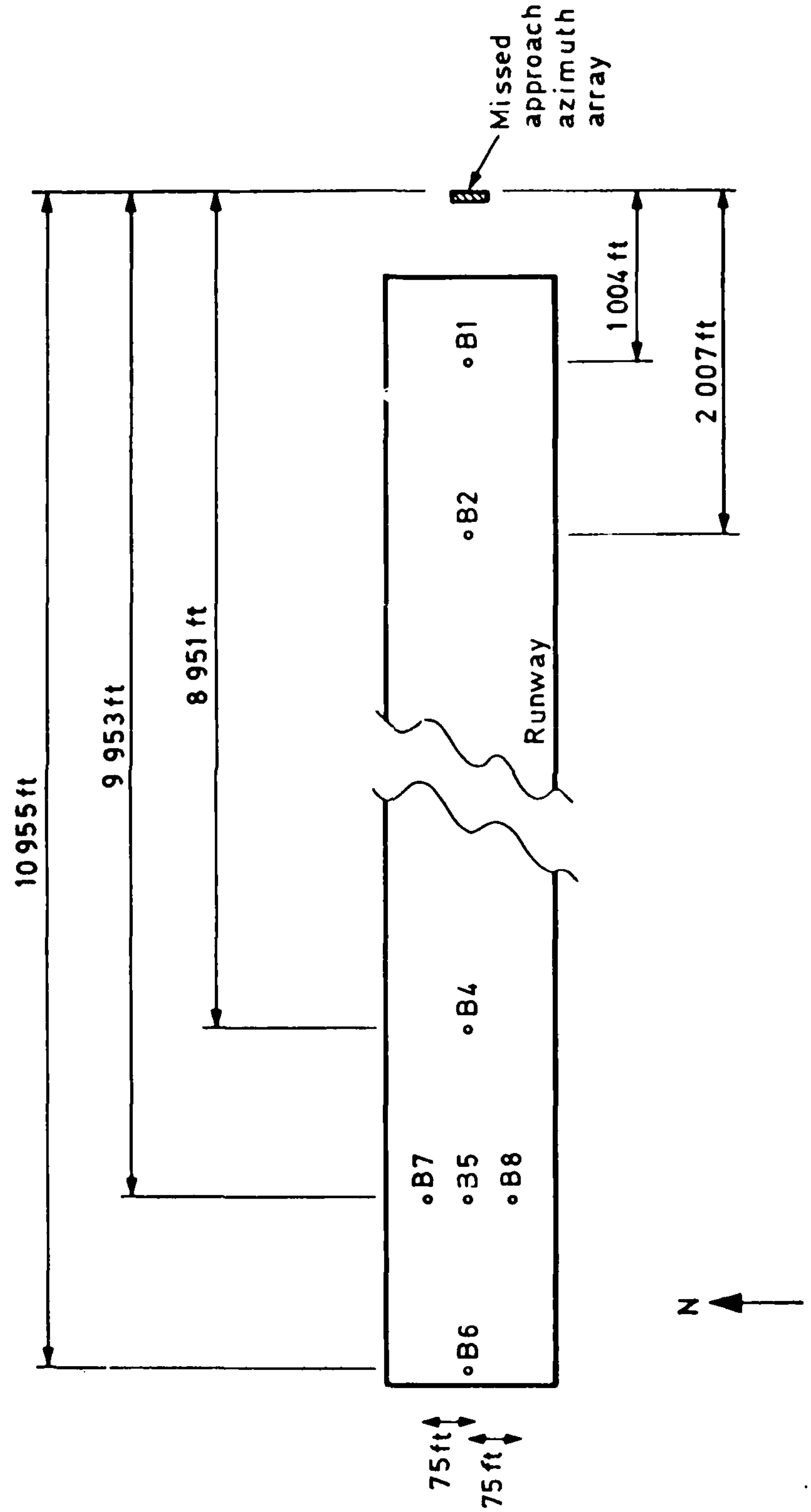


Fig 4.6a Close and long range missed approach azimuth test points

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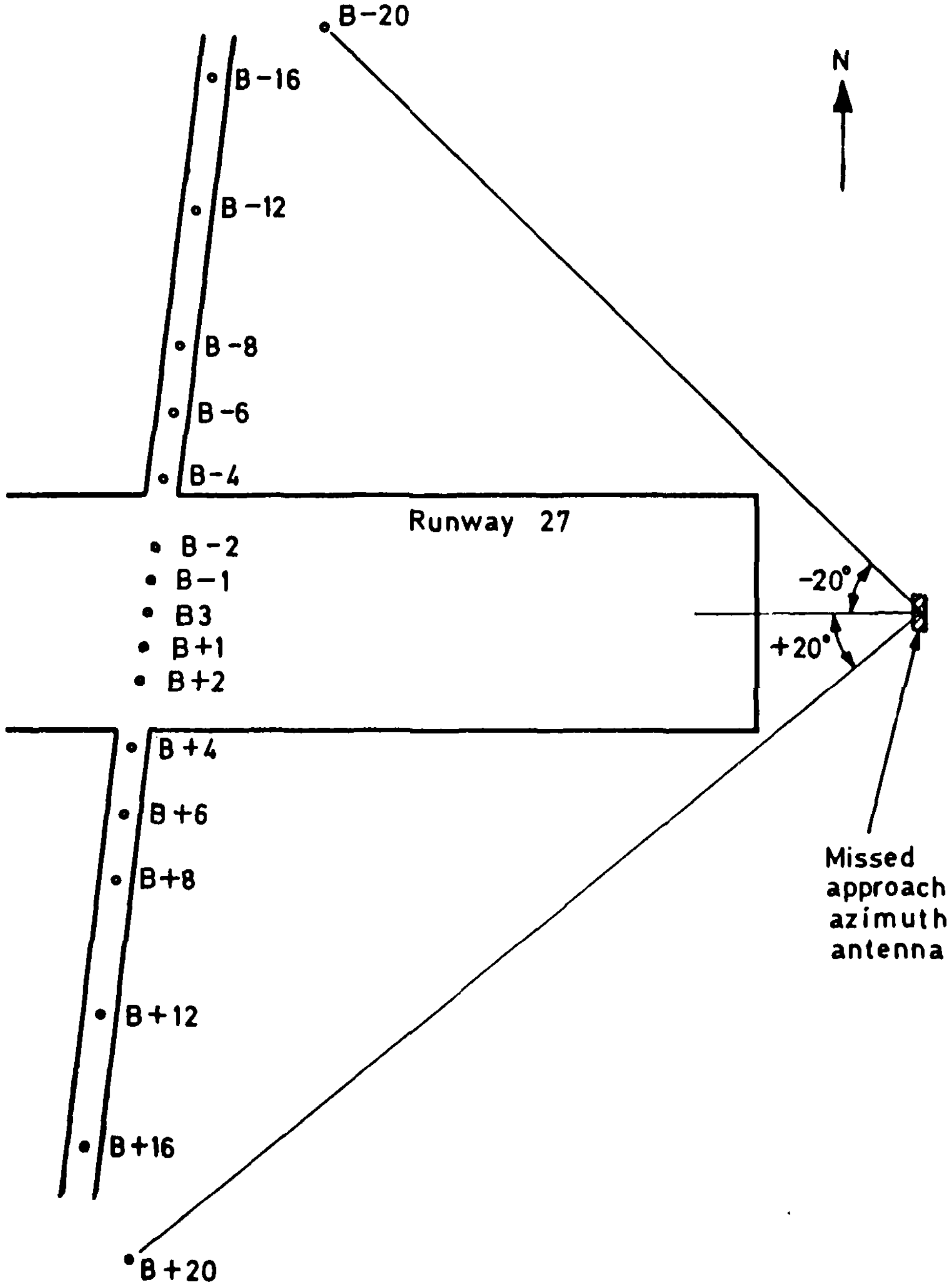


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Fig 4.6b Cross runway missed approach azimuth test points

Fig 4.7

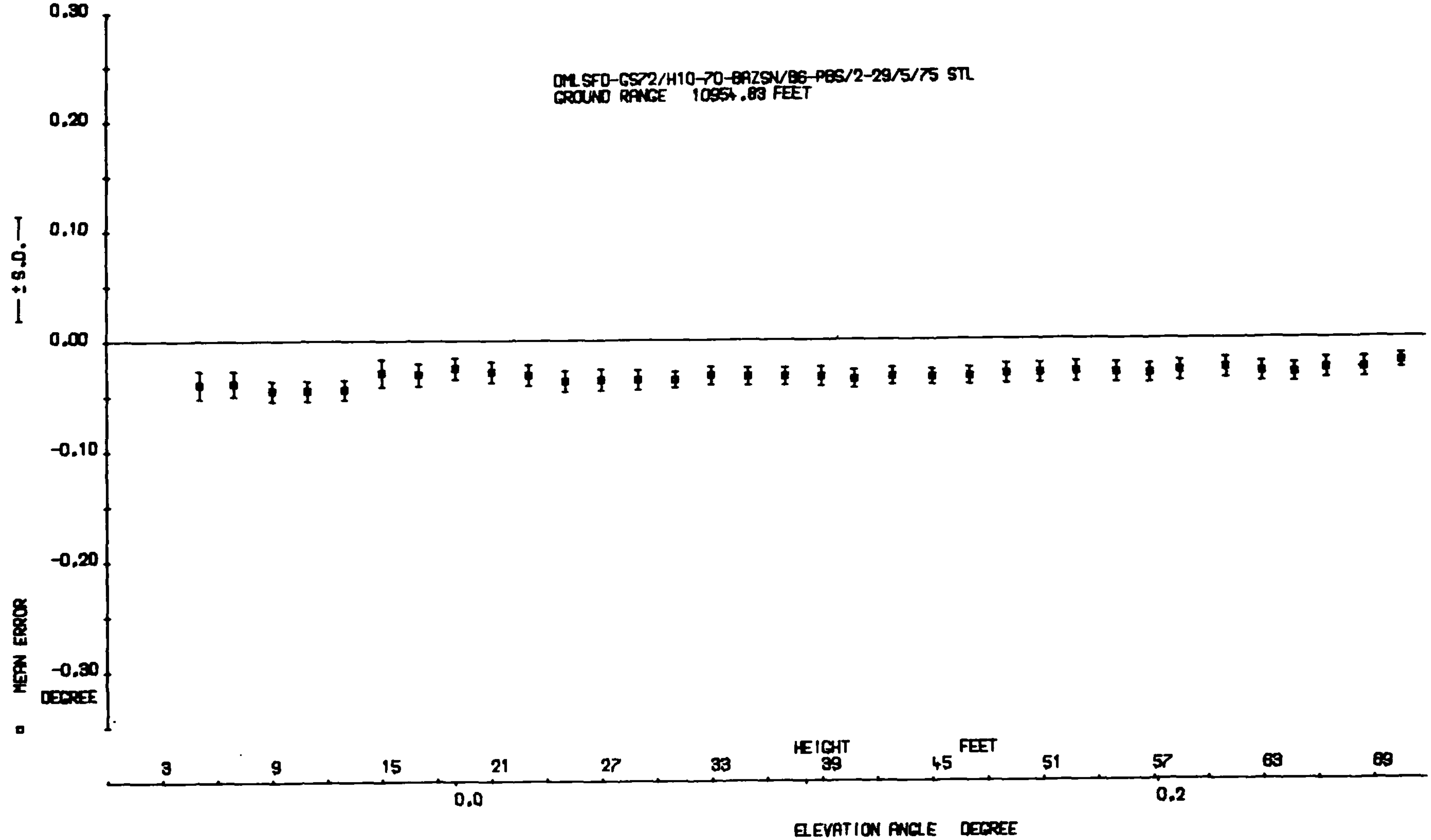


Fig 4.7 Missed approach azimuth static test GS72, position B6

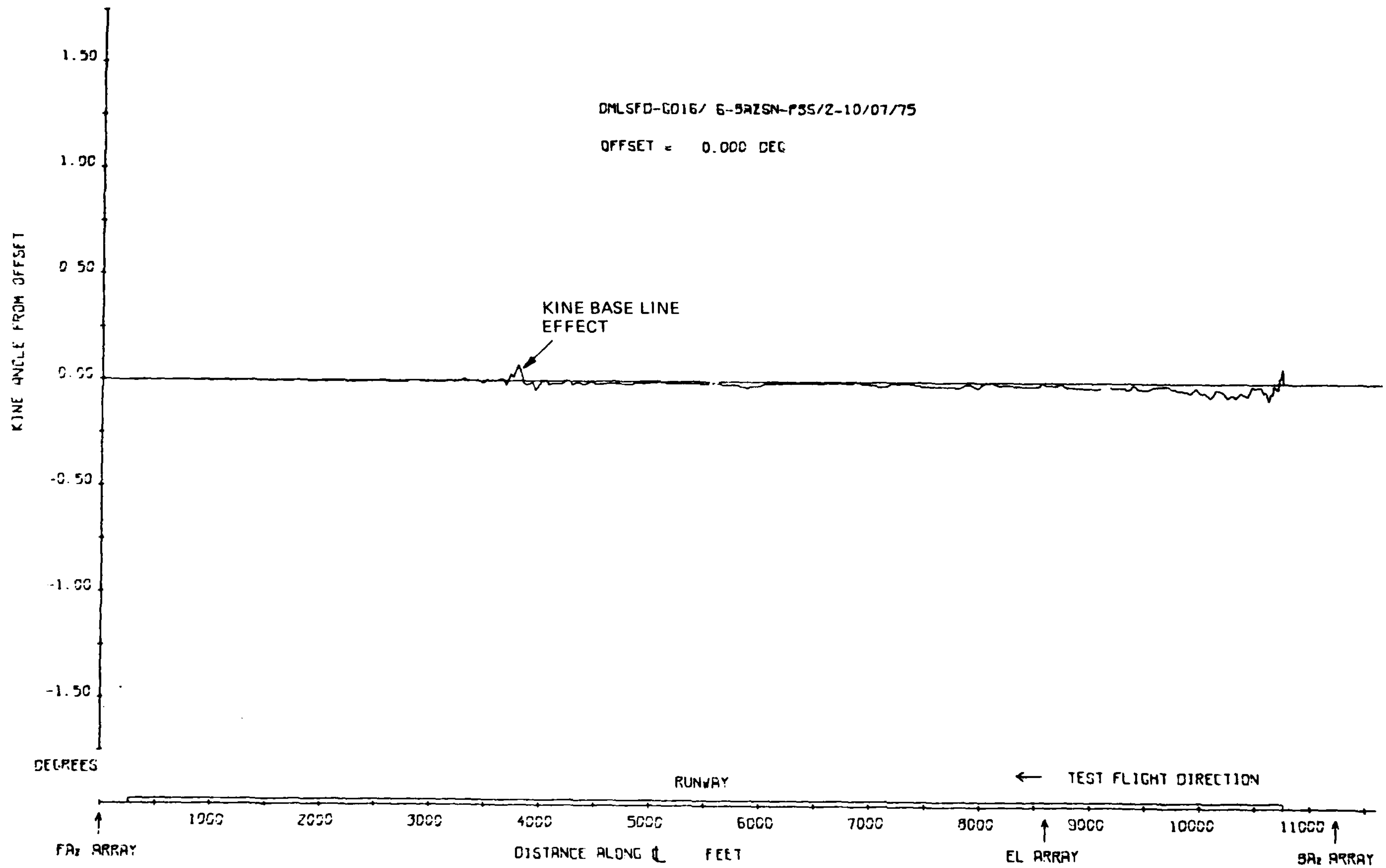


Fig 4.8a Missed approach azimuth. Run along test runway centre line. Mast at 20 ft

Fig 4.8a

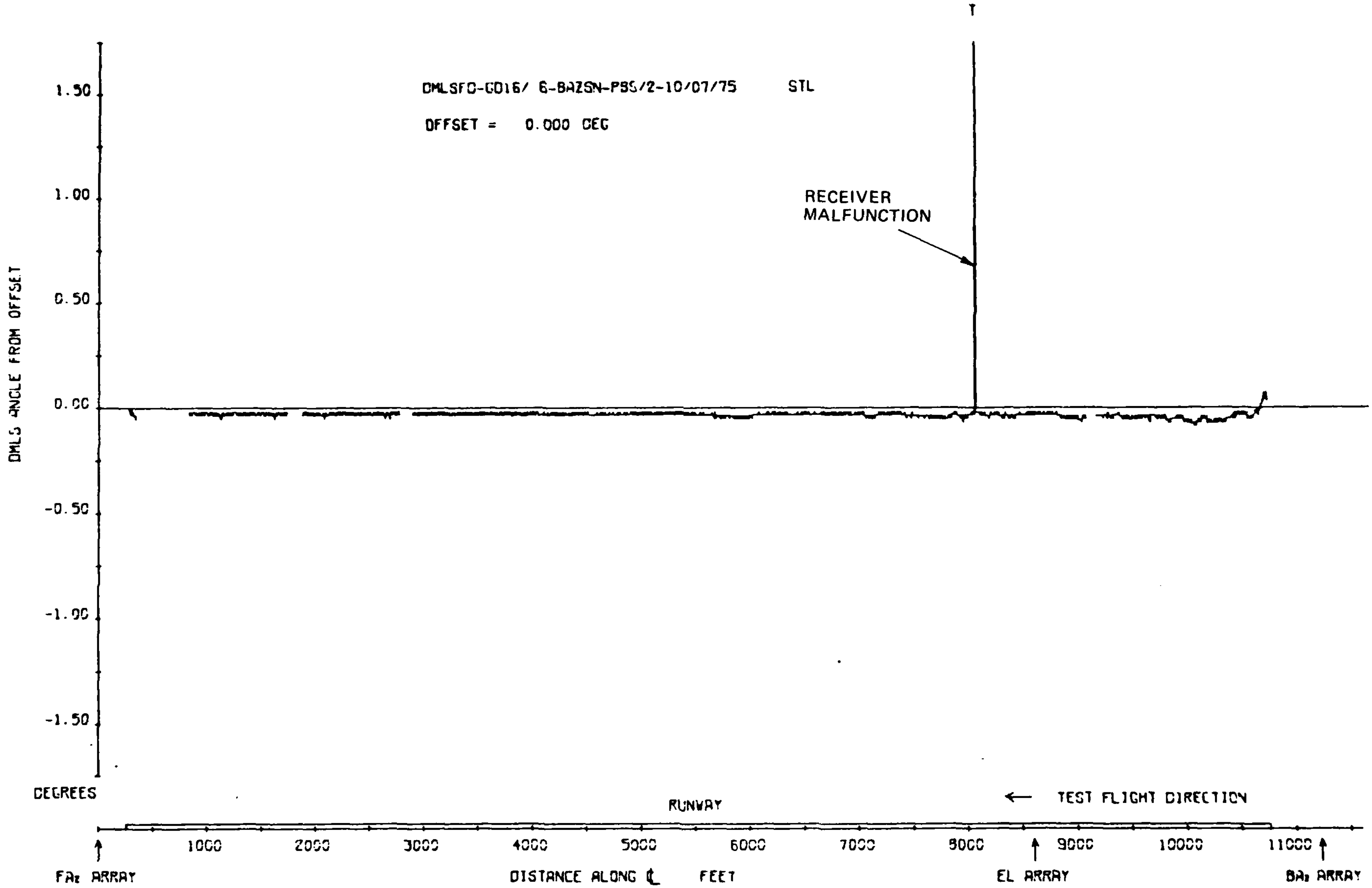


Fig 4.8b Missed approach azimuth. Run along test runway centre line. Mast at 20 ft

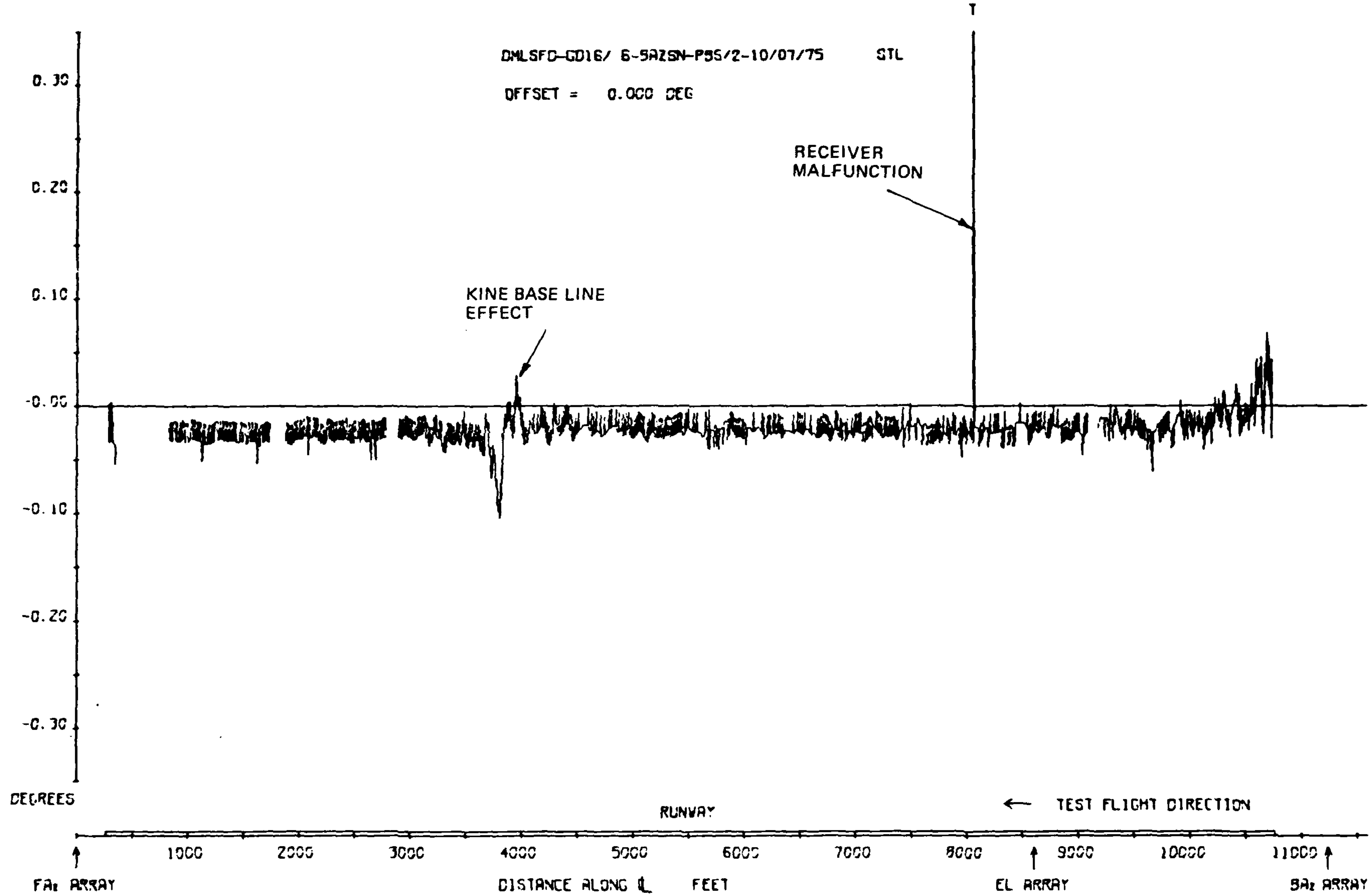


Fig 4.8c Missed approach azimuth. Run along test runway centre line. Mast at 20 ft

Fig 4.8c

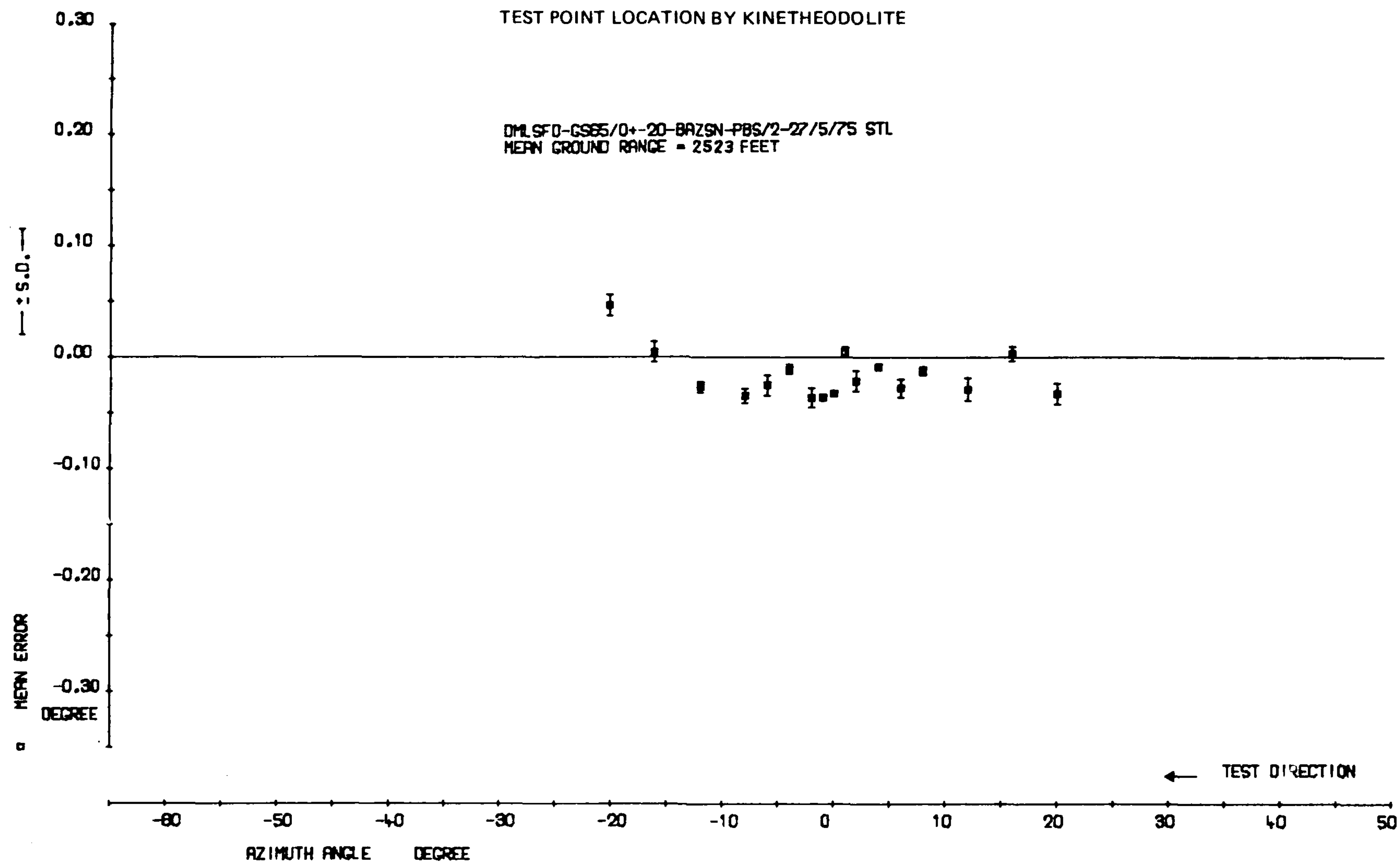


Fig 4.9 Missed approach azimuth cross runway test GS65

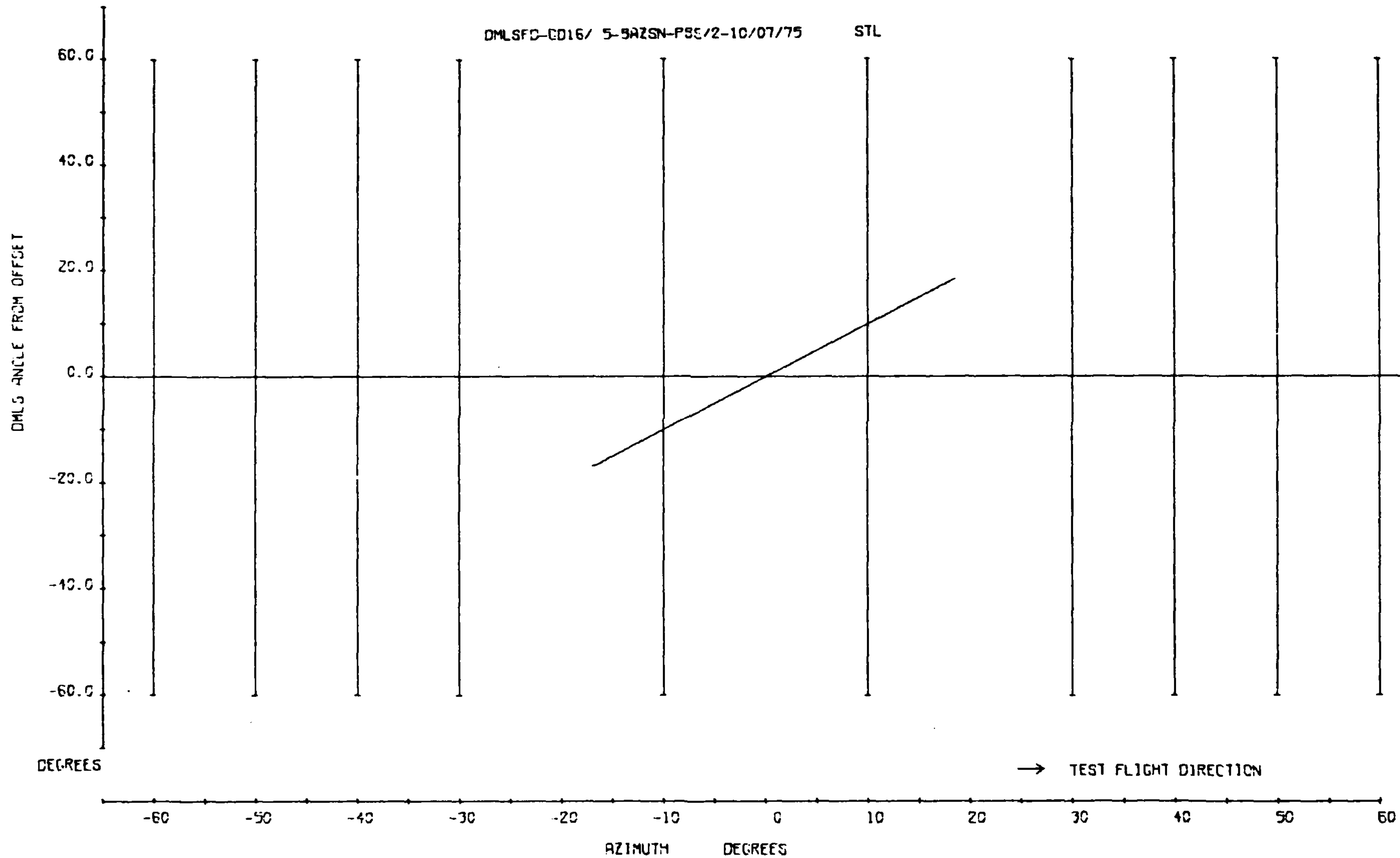


Fig 4.10a Missed approach azimuth. Vehicle run along cross road.
Mast height 20 ft

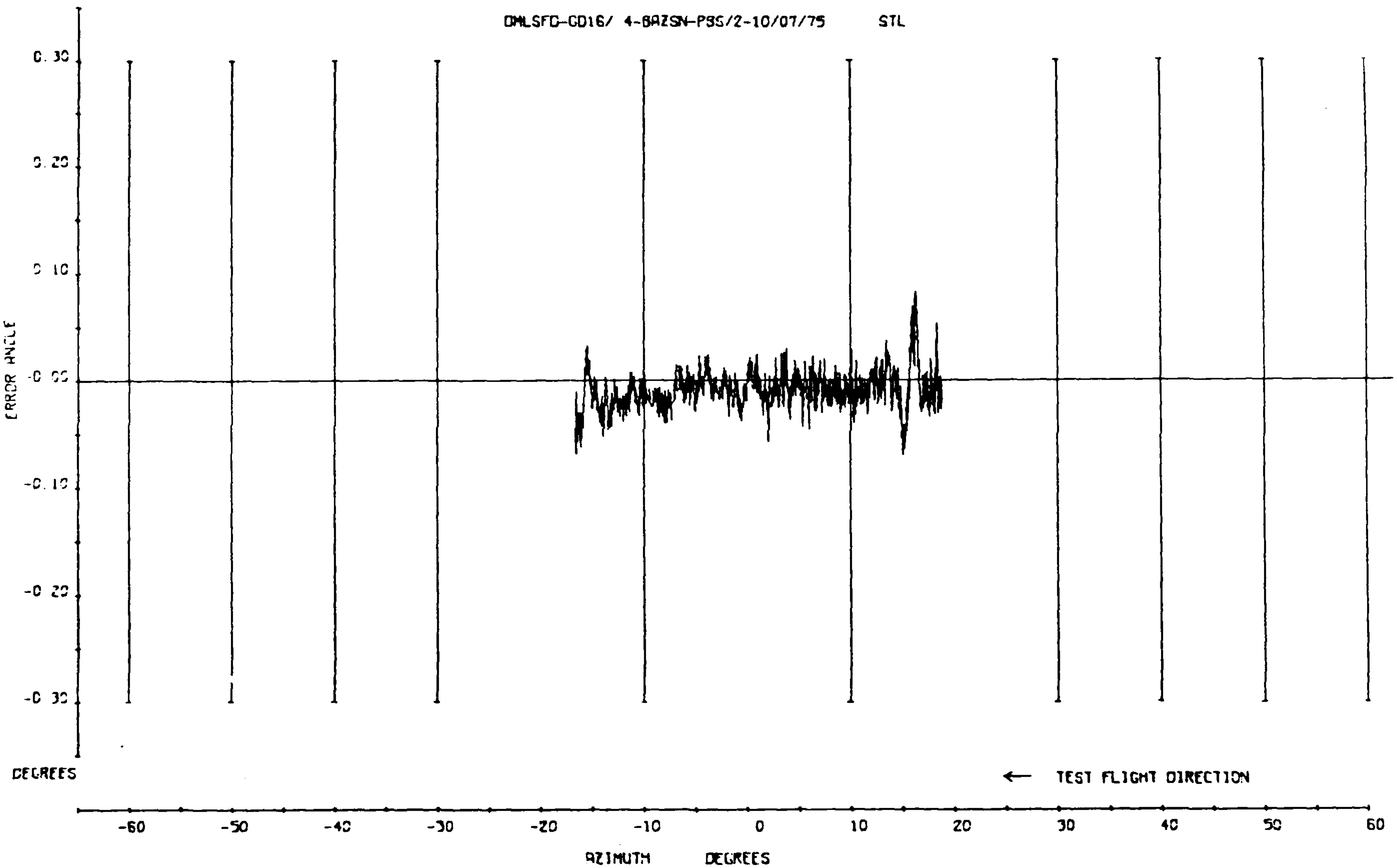


Fig 4.10b Missed approach azimuth. Vehicle run along cross road.
*Mast height 30 ft*

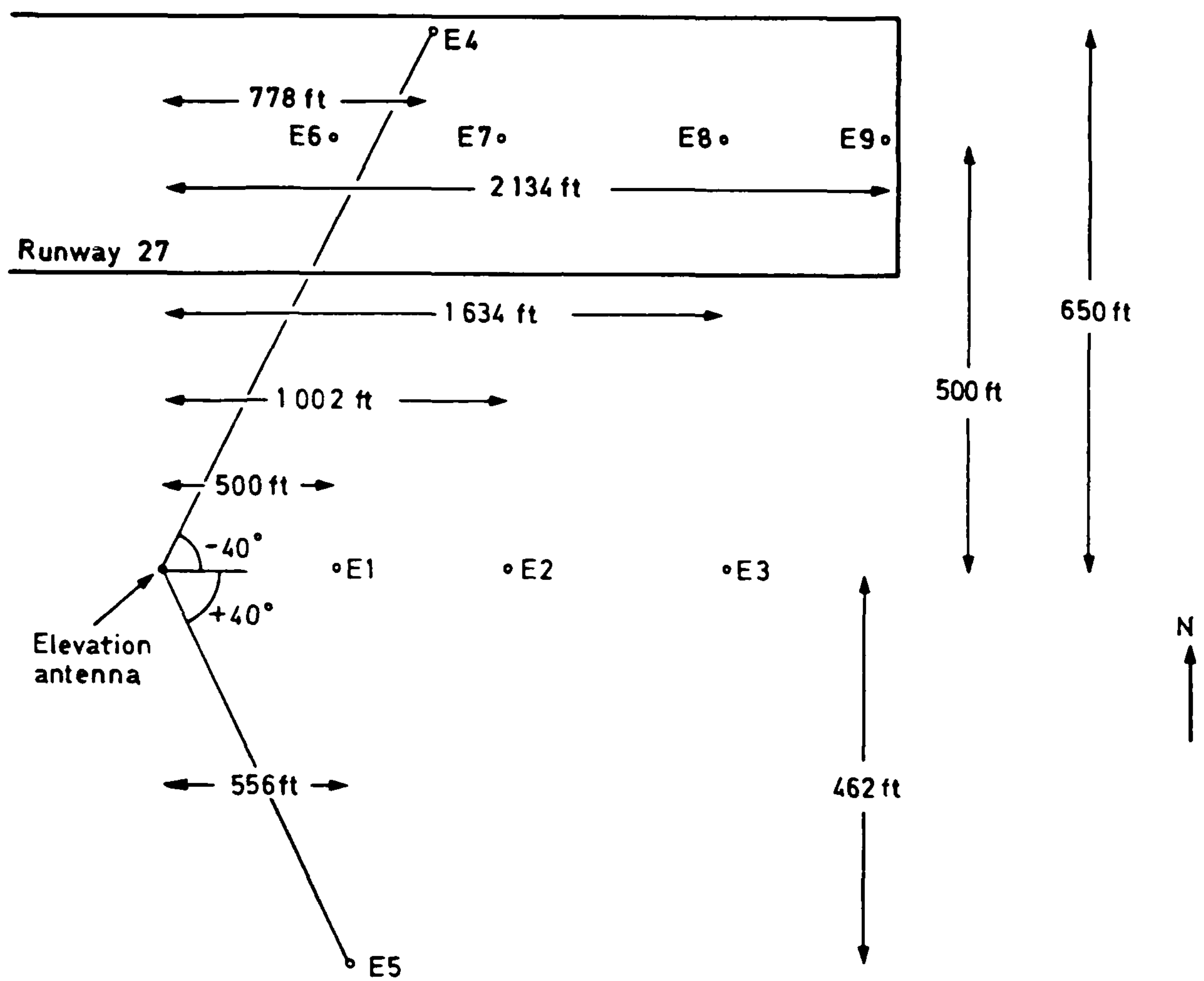


Fig 4.11 Elevation test points

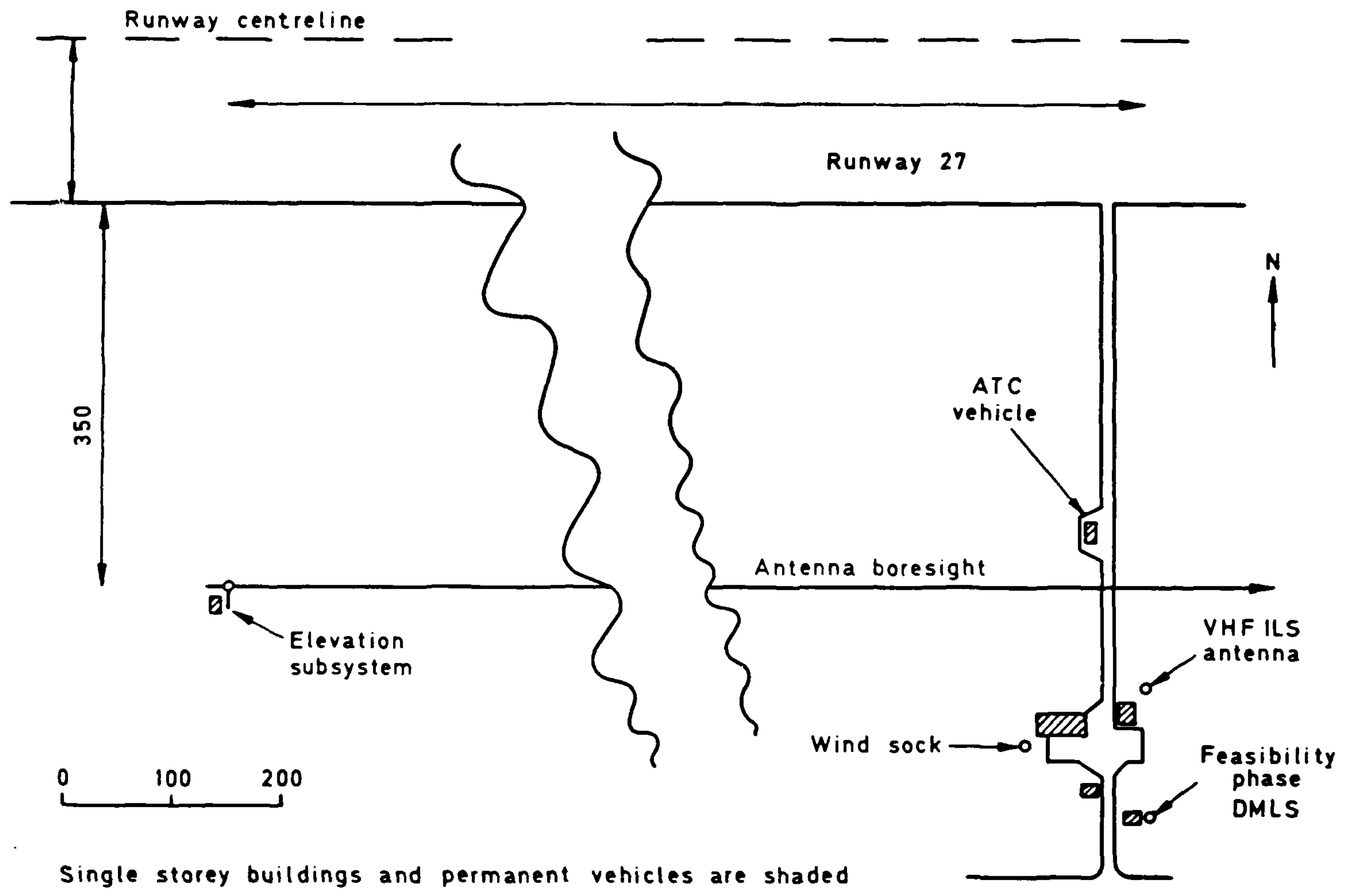


Fig 4.12 Elevation sub-system installation

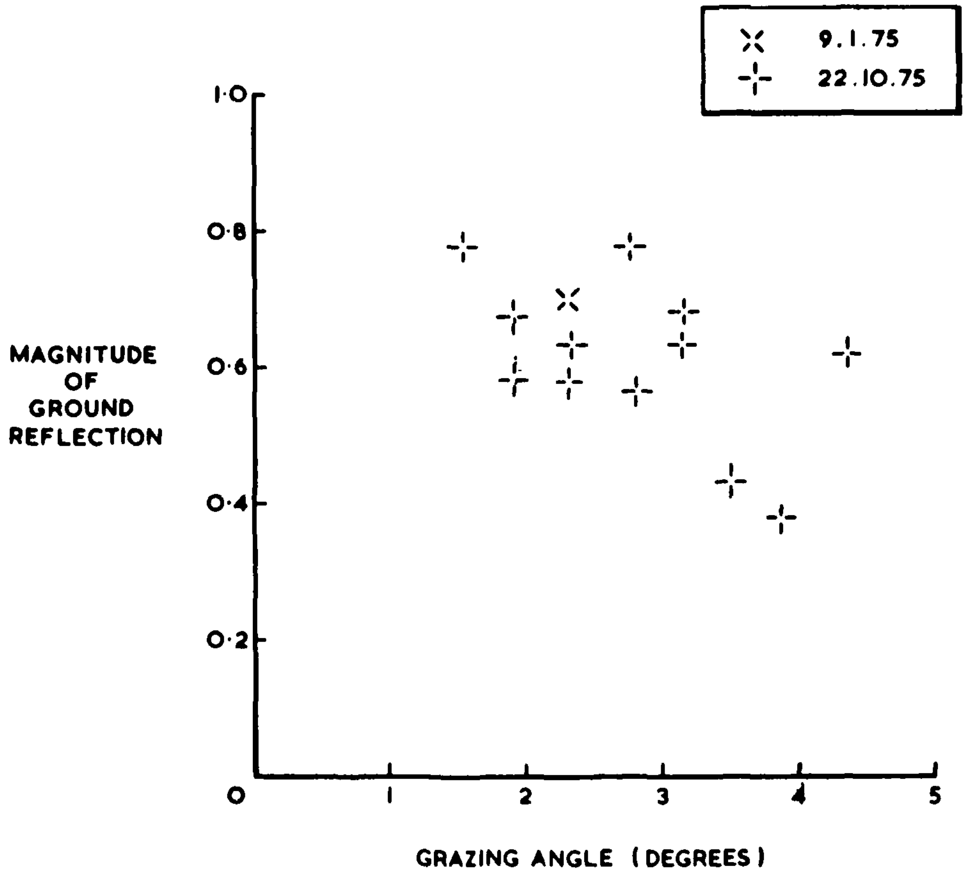


Fig 4.13 Magnitude of ground reflection in front of elevation transmitter. Range 1000 ft

Fig 4.14

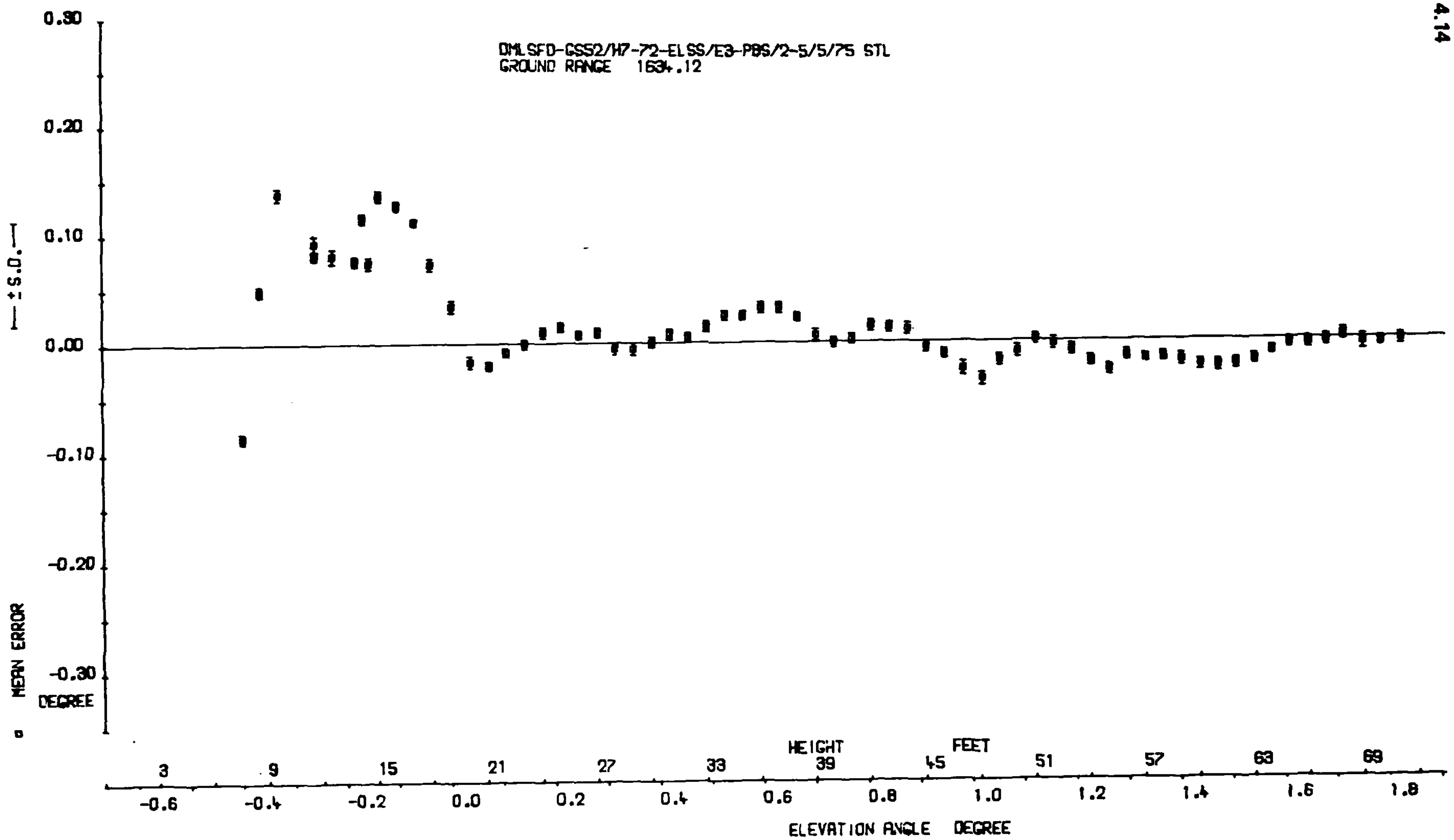


Fig 4.14 Elevation static test GS52, position E3

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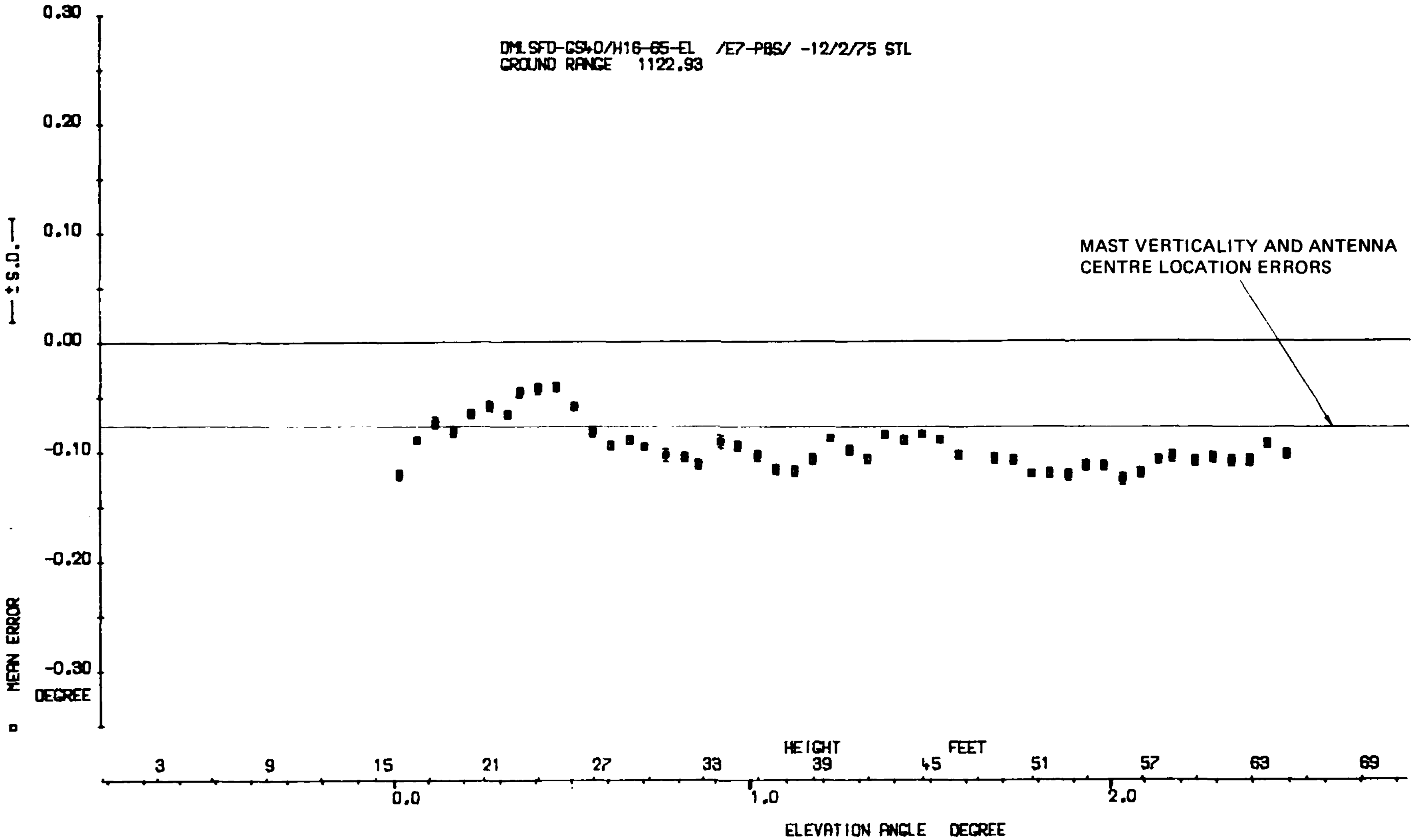


Fig 4.15a Elevation static test GS40, position E7

Fig 4.15b

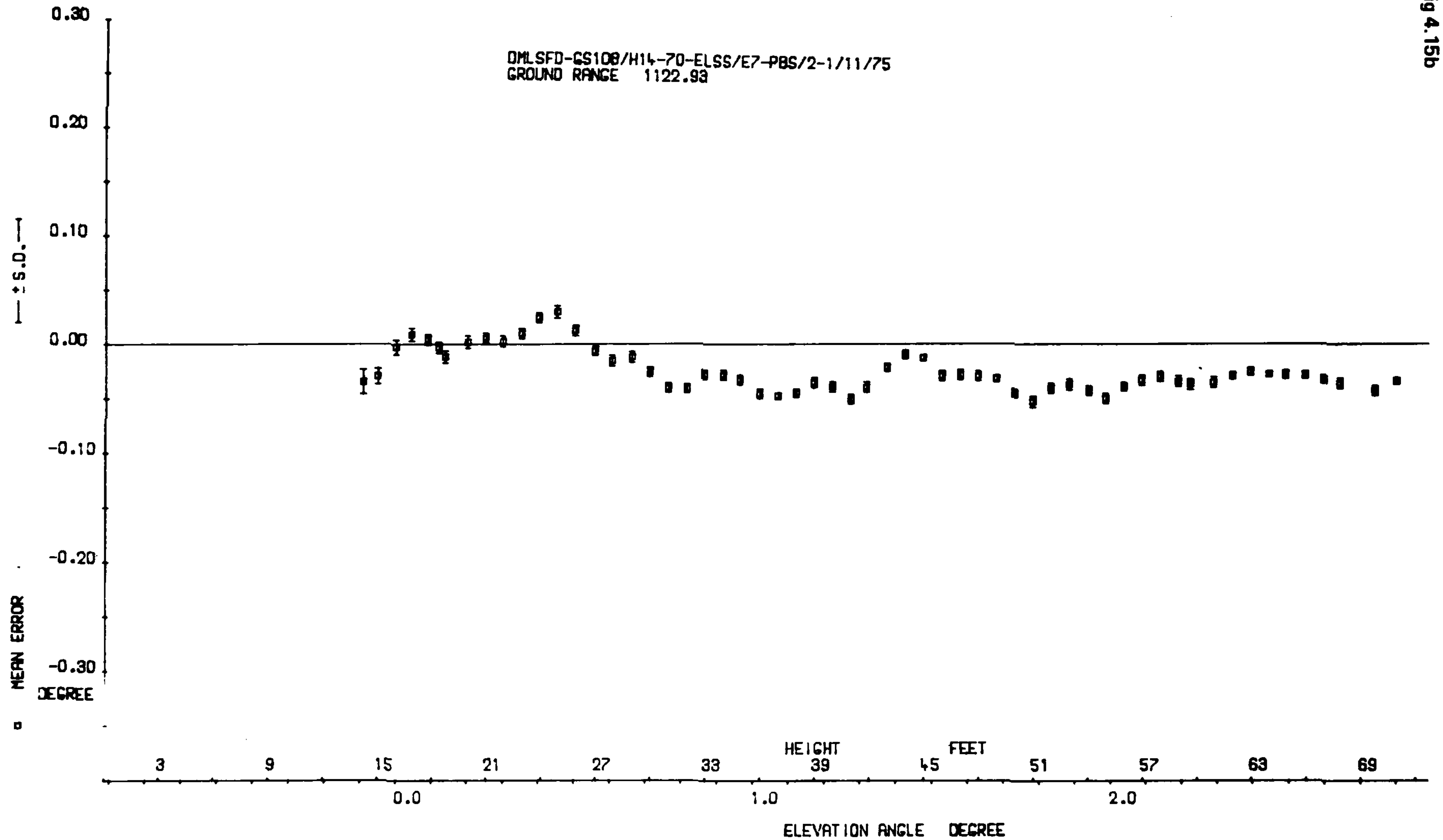


Fig 4.15b Elevation static test GS108, position E7

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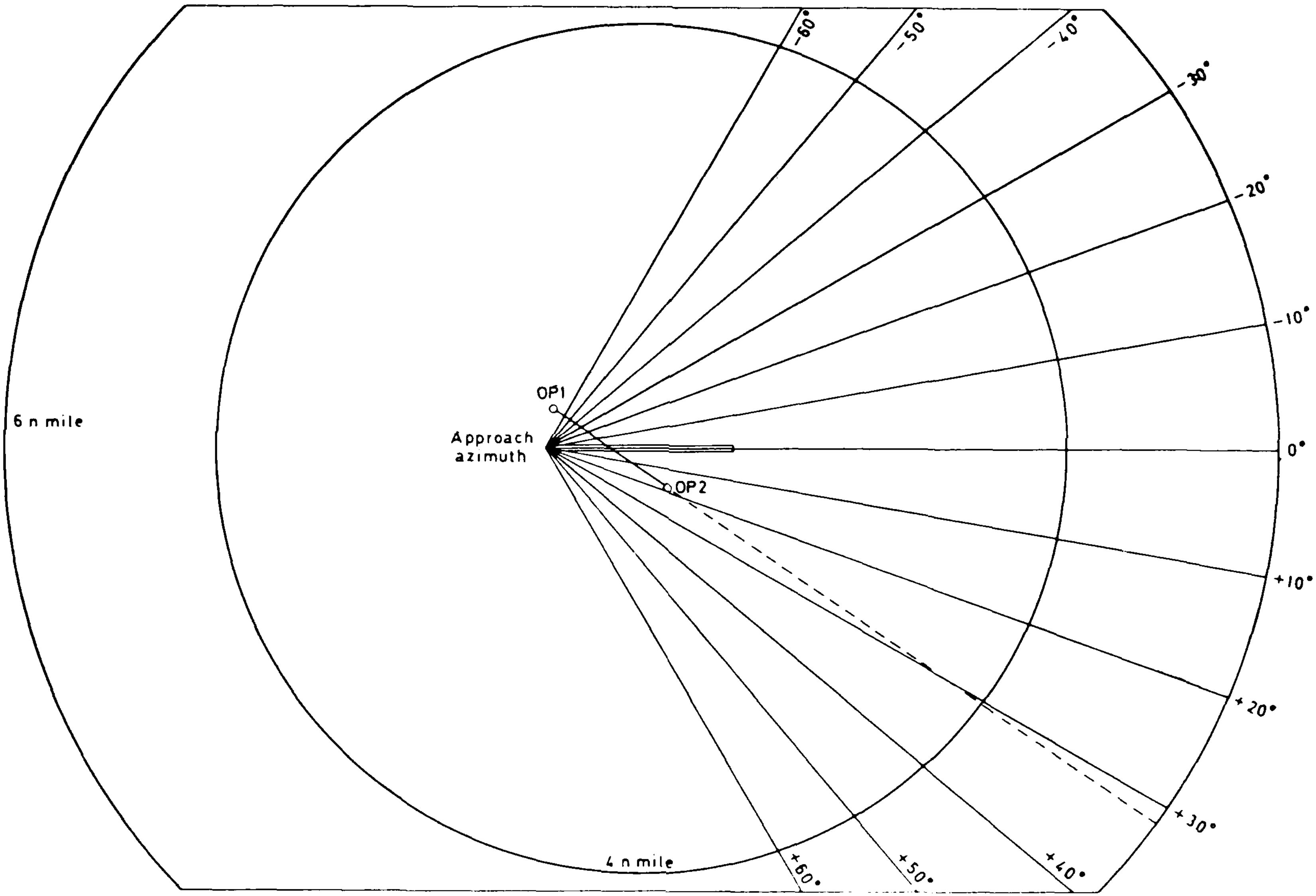


Fig 4.16a Kine base line in relation to approach azimuth flight paths

Fig 4.16b

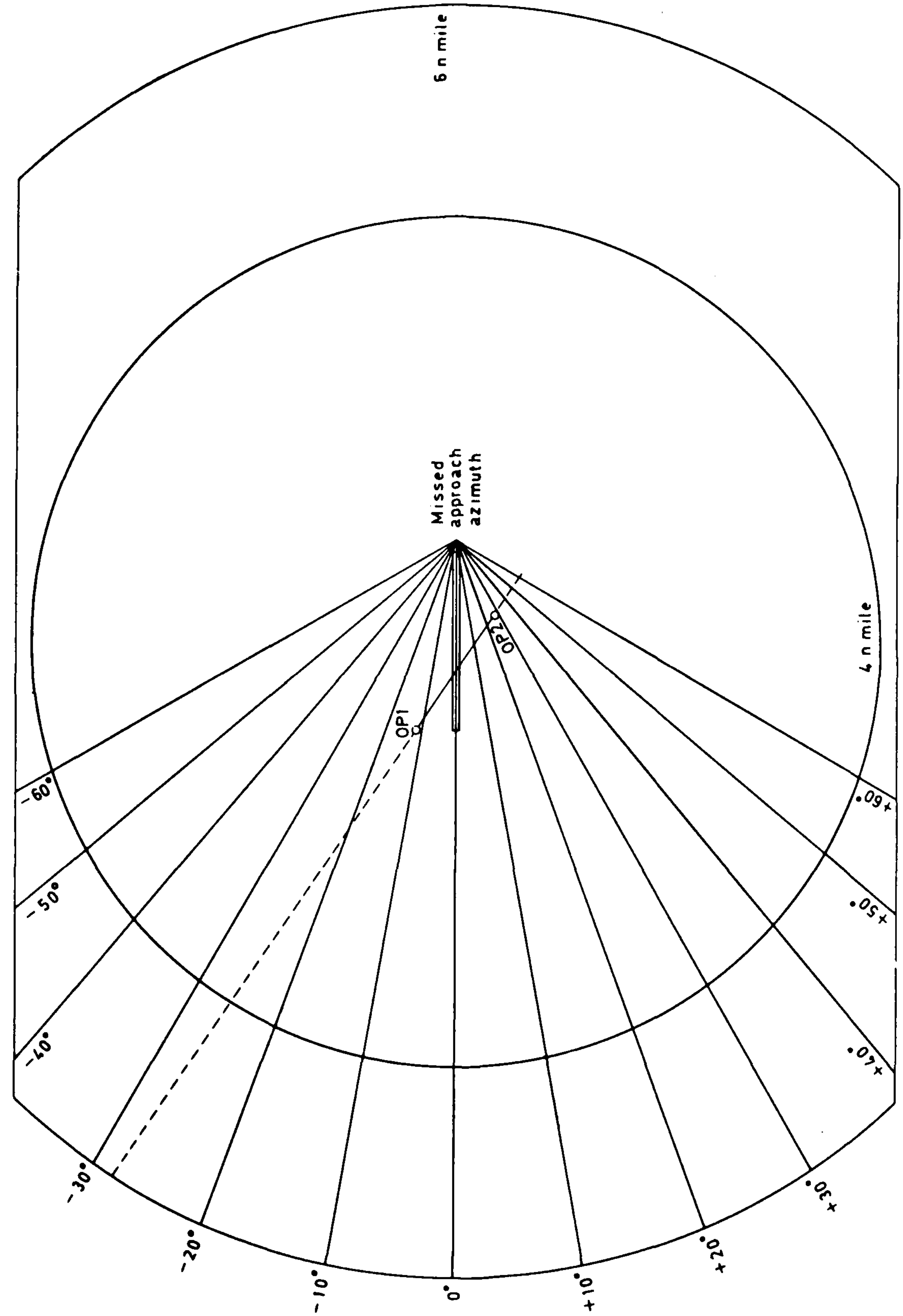


Fig 4.16b Kine base line in relation to missed approach azimuth flight paths

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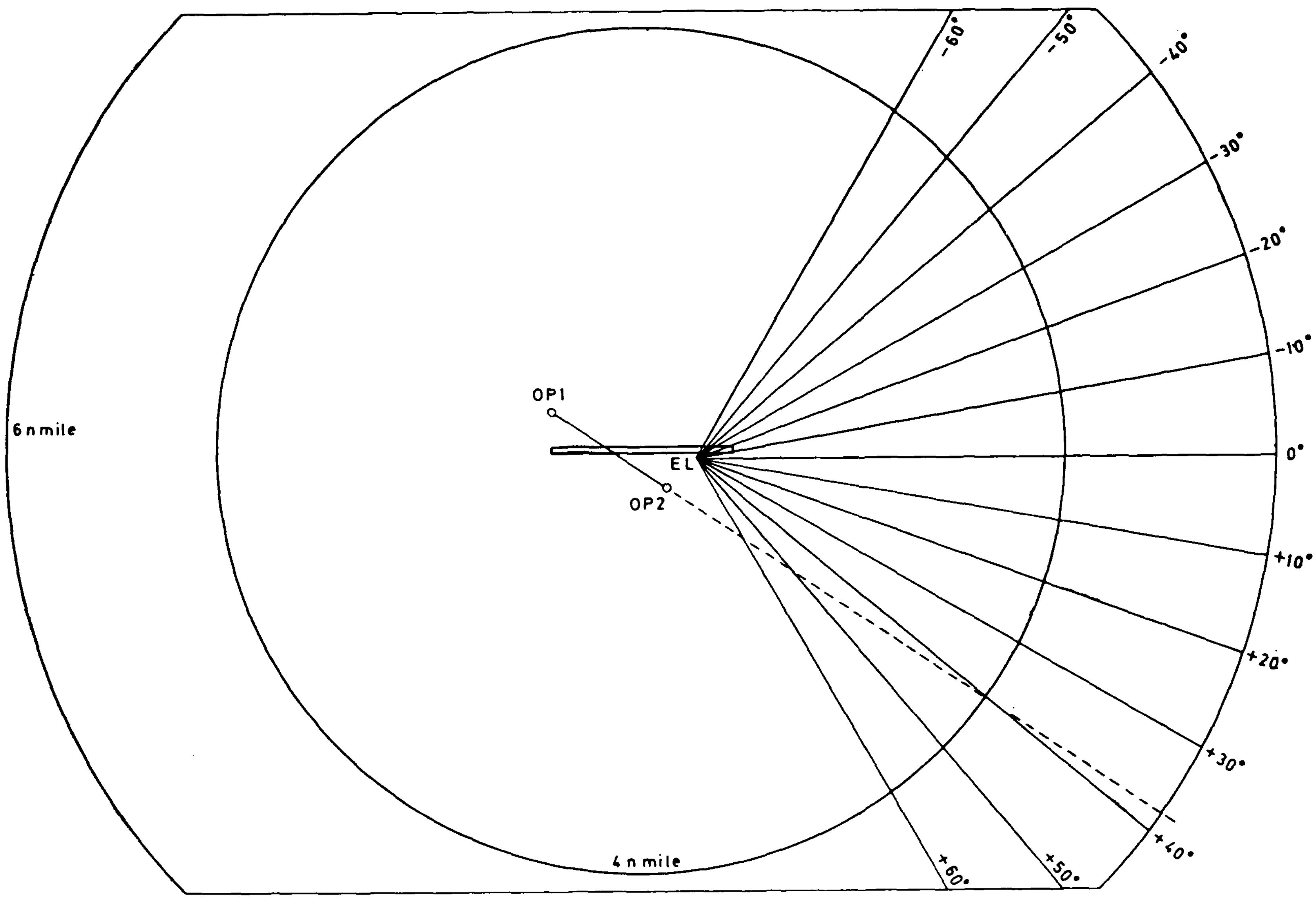


Fig 4.16c Kine base line in relation to elevation flight paths

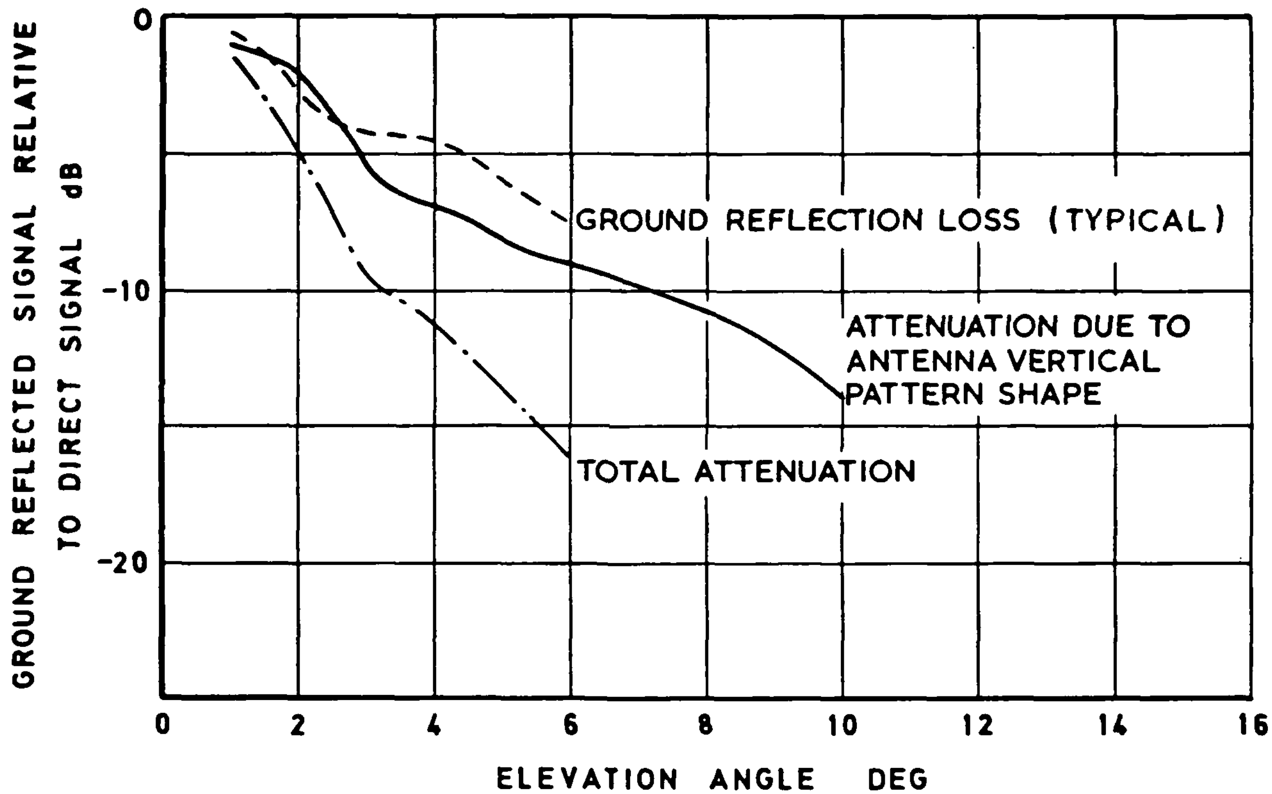


Fig 4.17 Estimated ground reflected signal for azimuth ground plane antenna

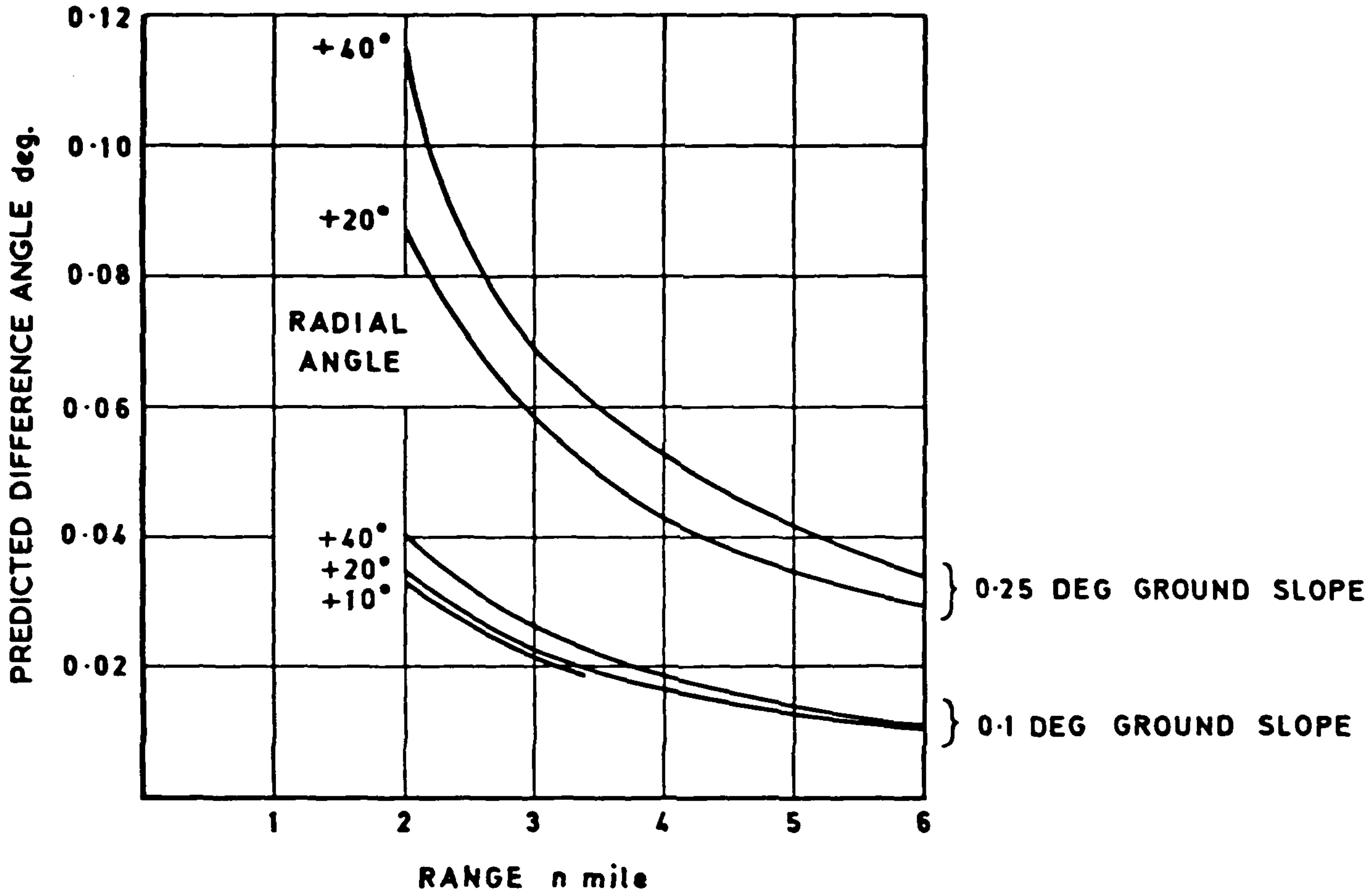


Fig 4.18 Predicted code angle difference between direct and ground reflected signal for 0.1 and 0.25 degree lateral slope during 2000 ft constant height radials

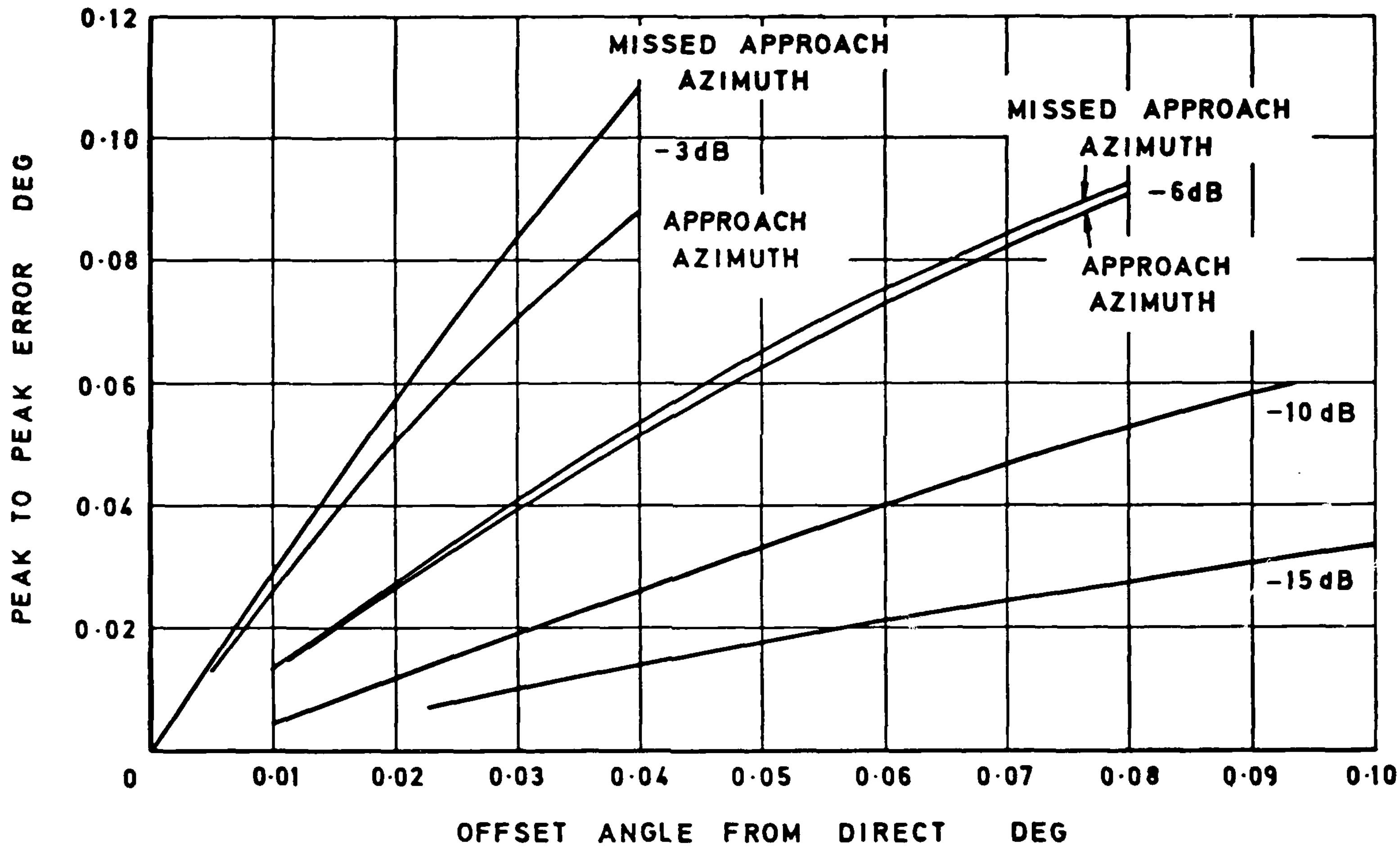


Fig 4.19 Calculated peak to peak error as a function of offset angle between direct and interfering signal

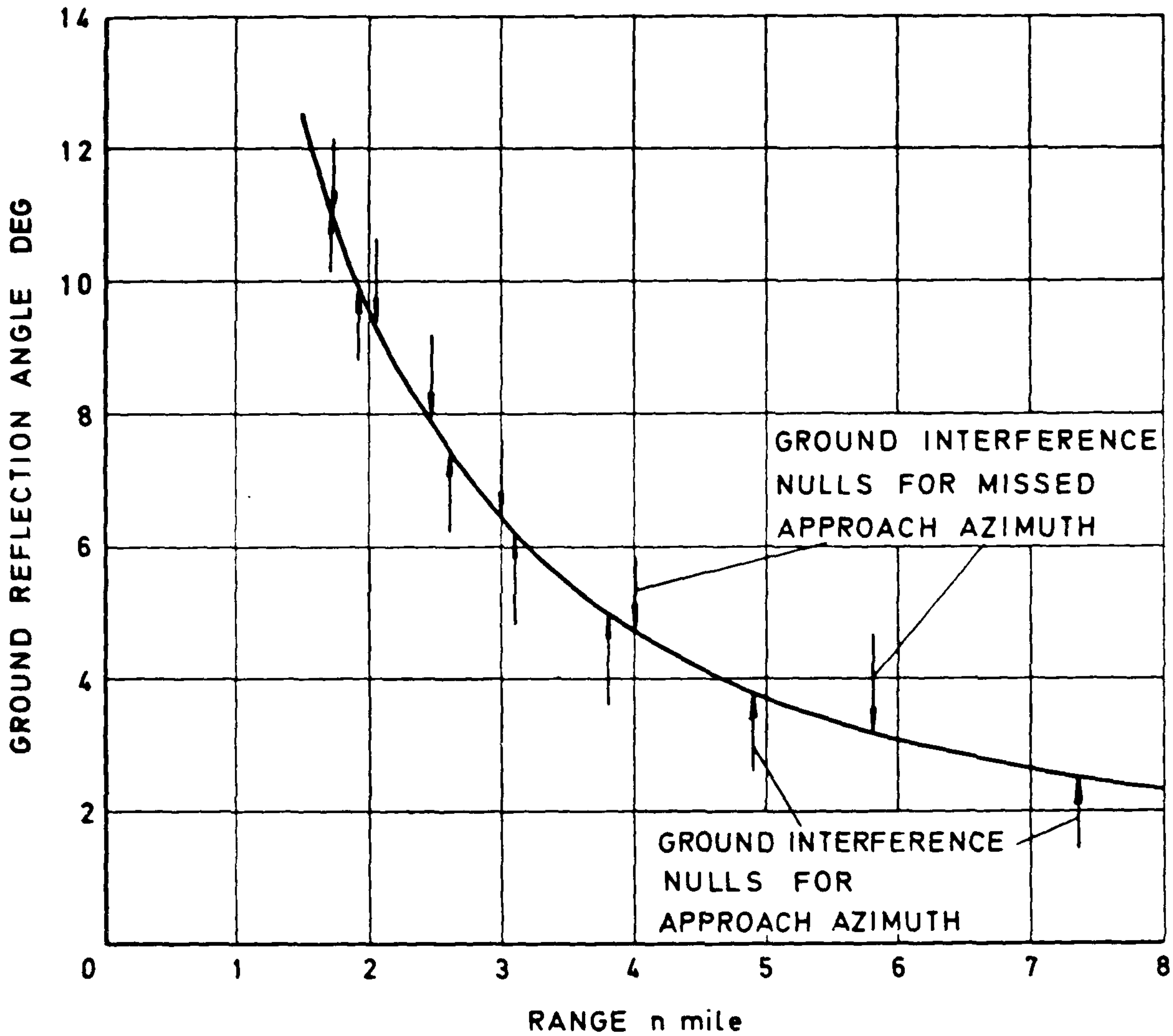


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Fig 4.20 Elevation angle and ground interference nulls for 2000 ft constant height radials

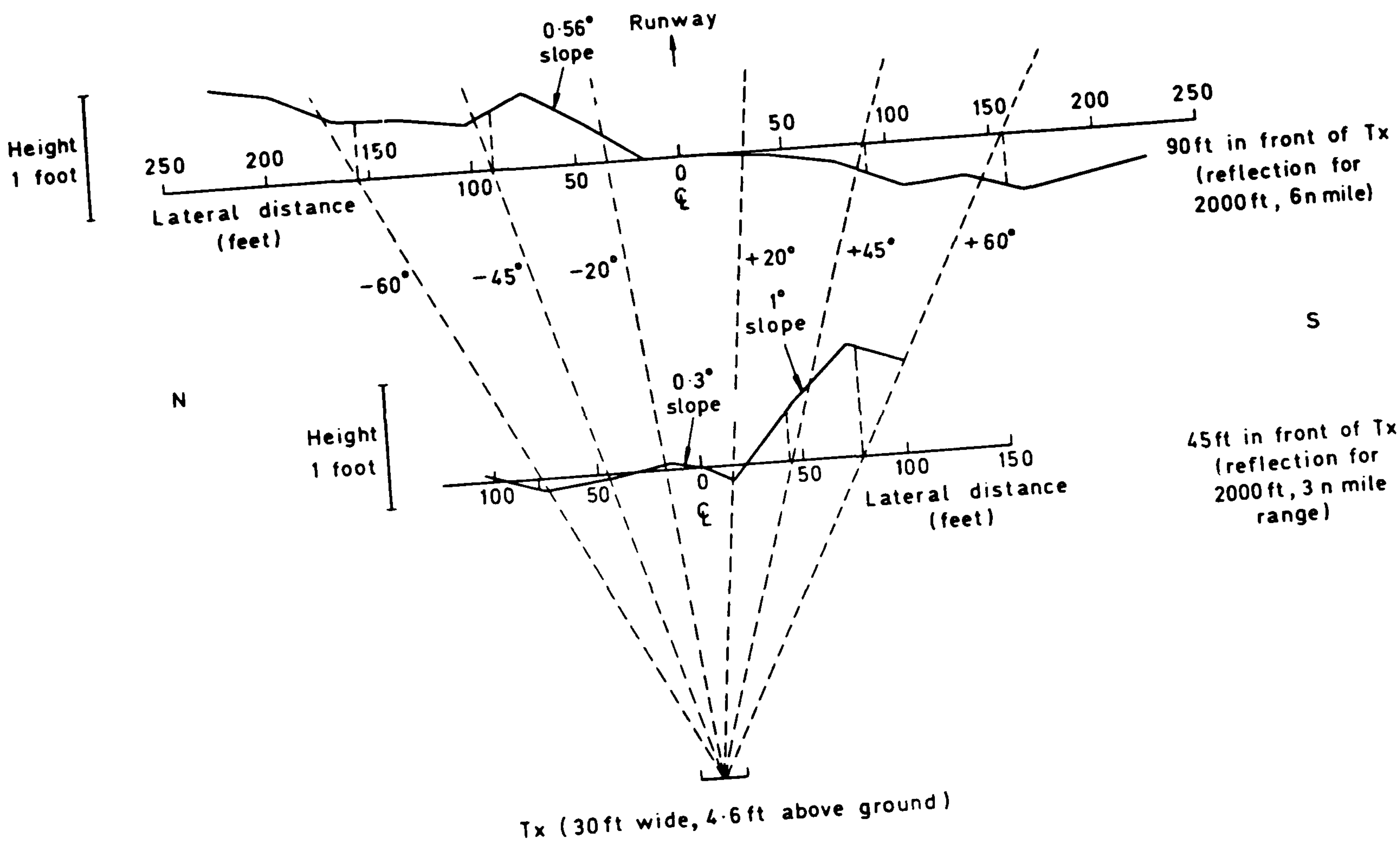


Fig 4.21a Lateral ground slope in front of approach azimuth transmitter

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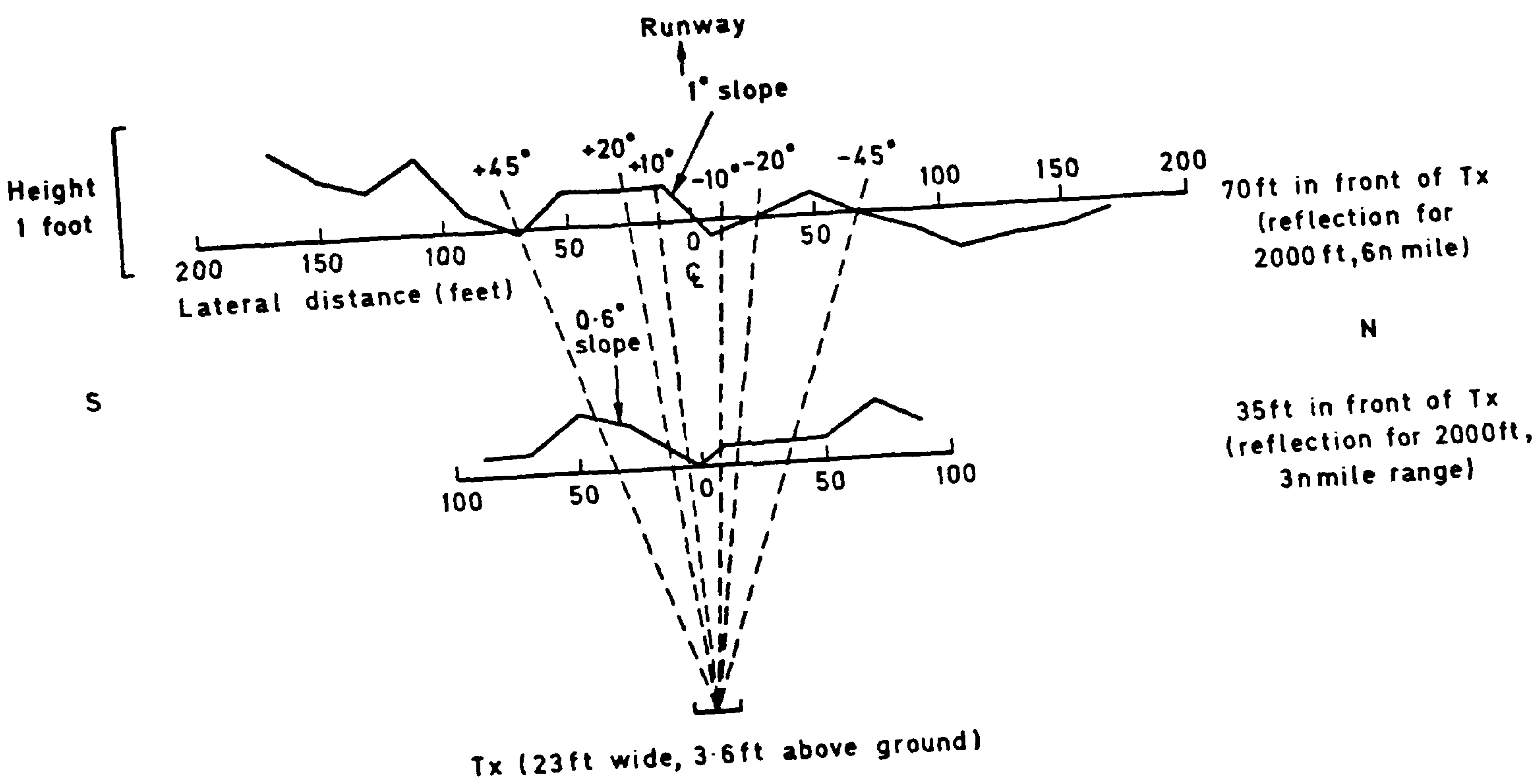
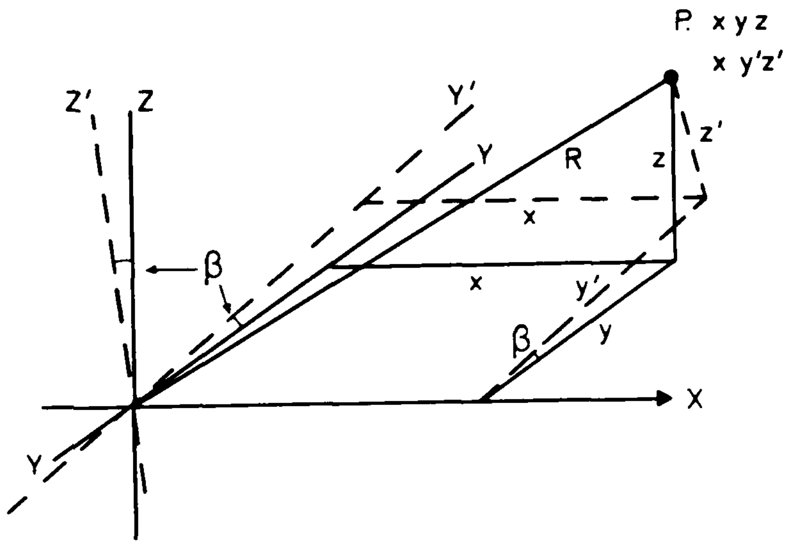



Fig 4.21b Lateral ground slope in front of missed approach azimuth transmitter




True azimuth code angle = $\phi$

$$\text{Cos } \phi = \frac{y}{R}$$

Tilted array axis is Y'Y'

Array code angle = $\phi'$

$$\text{Cos } \phi' = \frac{y'}{R} = \frac{1}{R}\left[\frac{y}{\cos\beta} + (Z - y\tan\beta)\sin\beta\right]$$

$$= \frac{1}{R}\left[Z\sin\beta + y\left(\frac{1-\sin^2\beta}{\cos\beta}\right)\right]$$

$$= \frac{1}{R}(Z\sin\beta + y\cos\beta)$$

$$= \sin\theta\sin\beta + \cos\phi\cos\beta$$

Fig 4.22 Azimuth antenna tilt errors

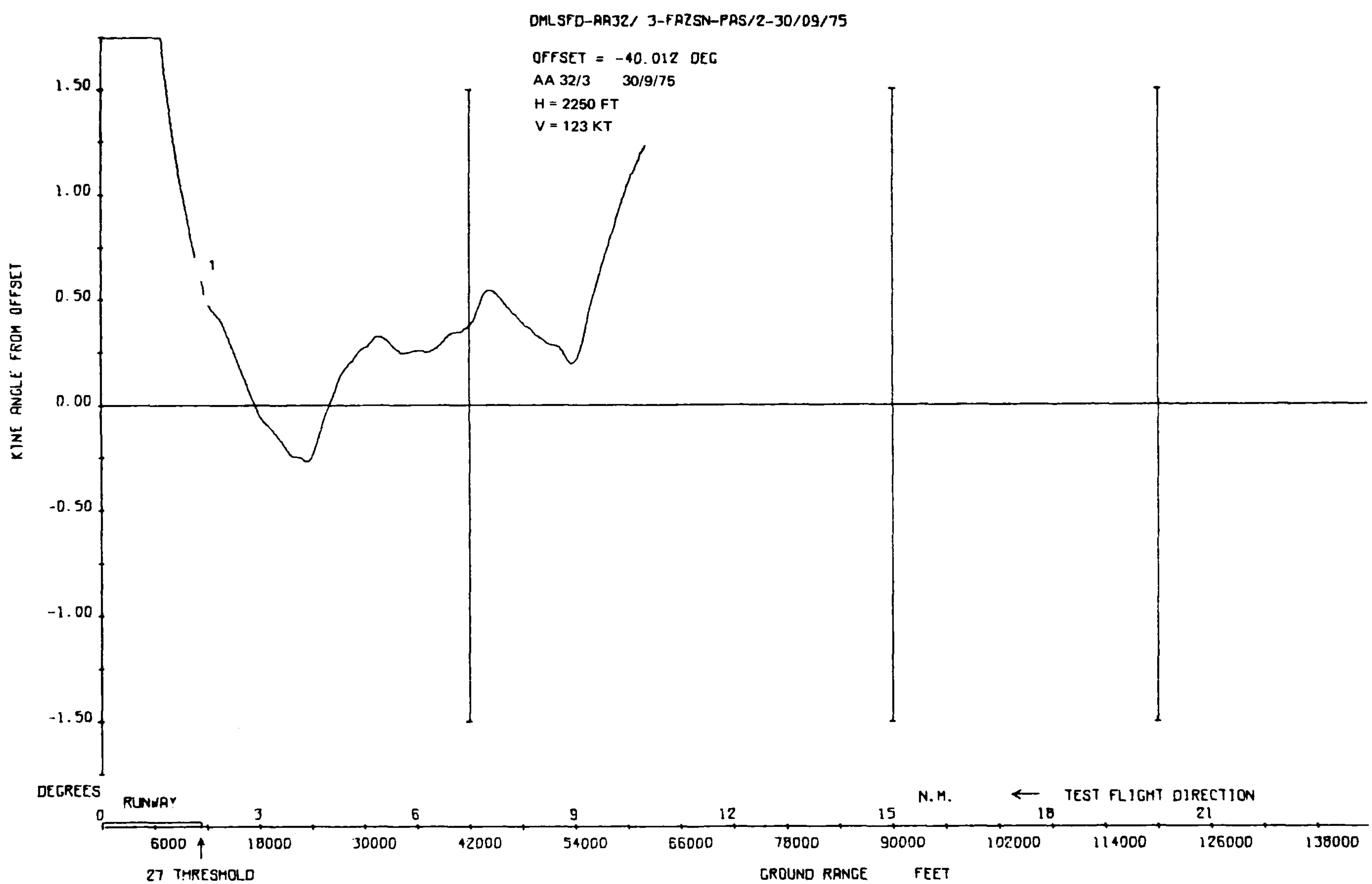



Fig 4.23a Approach azimuth radial at –40 degrees

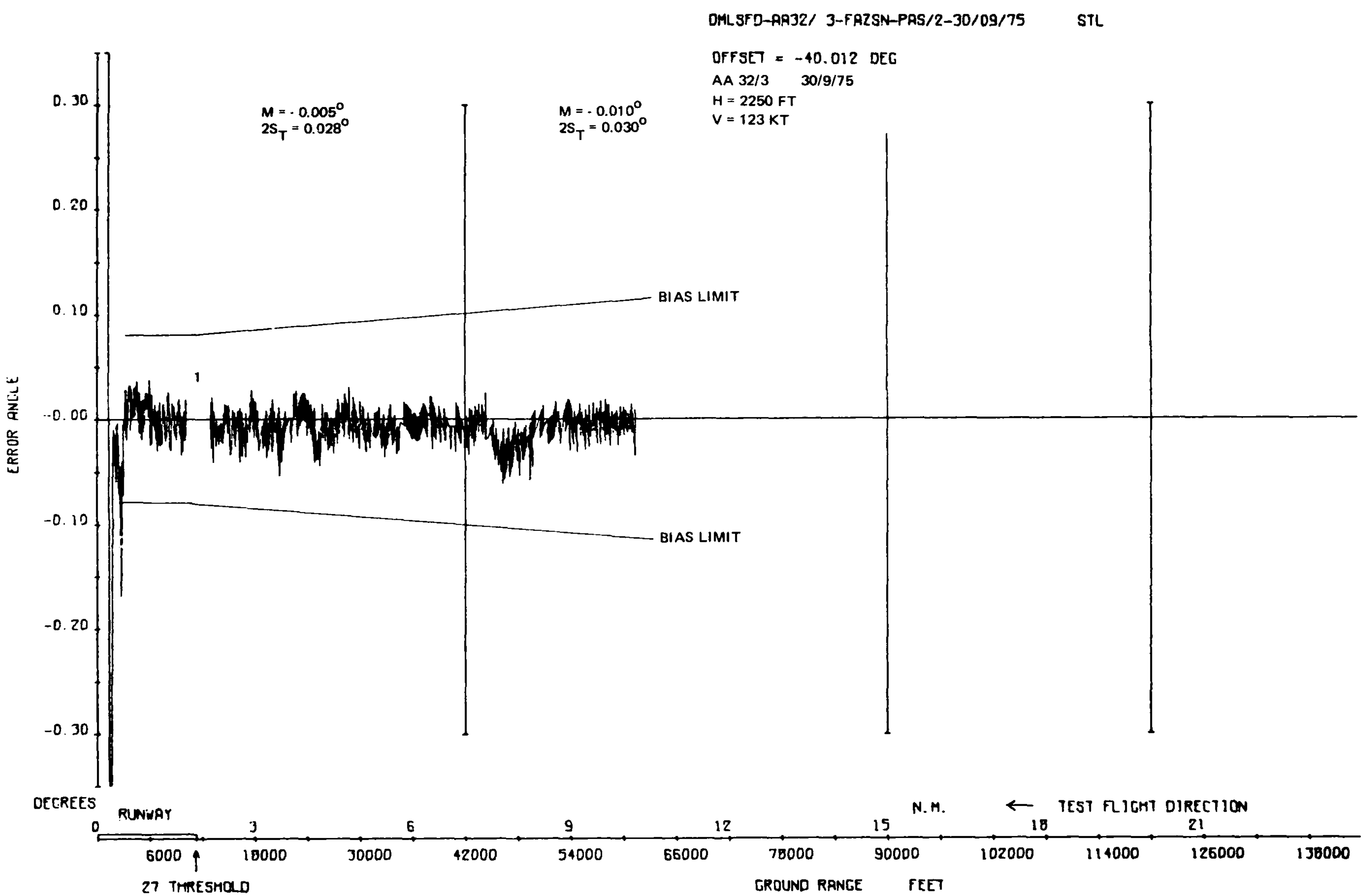



Fig 4.23c Approach azimuth radial at —40 degrees

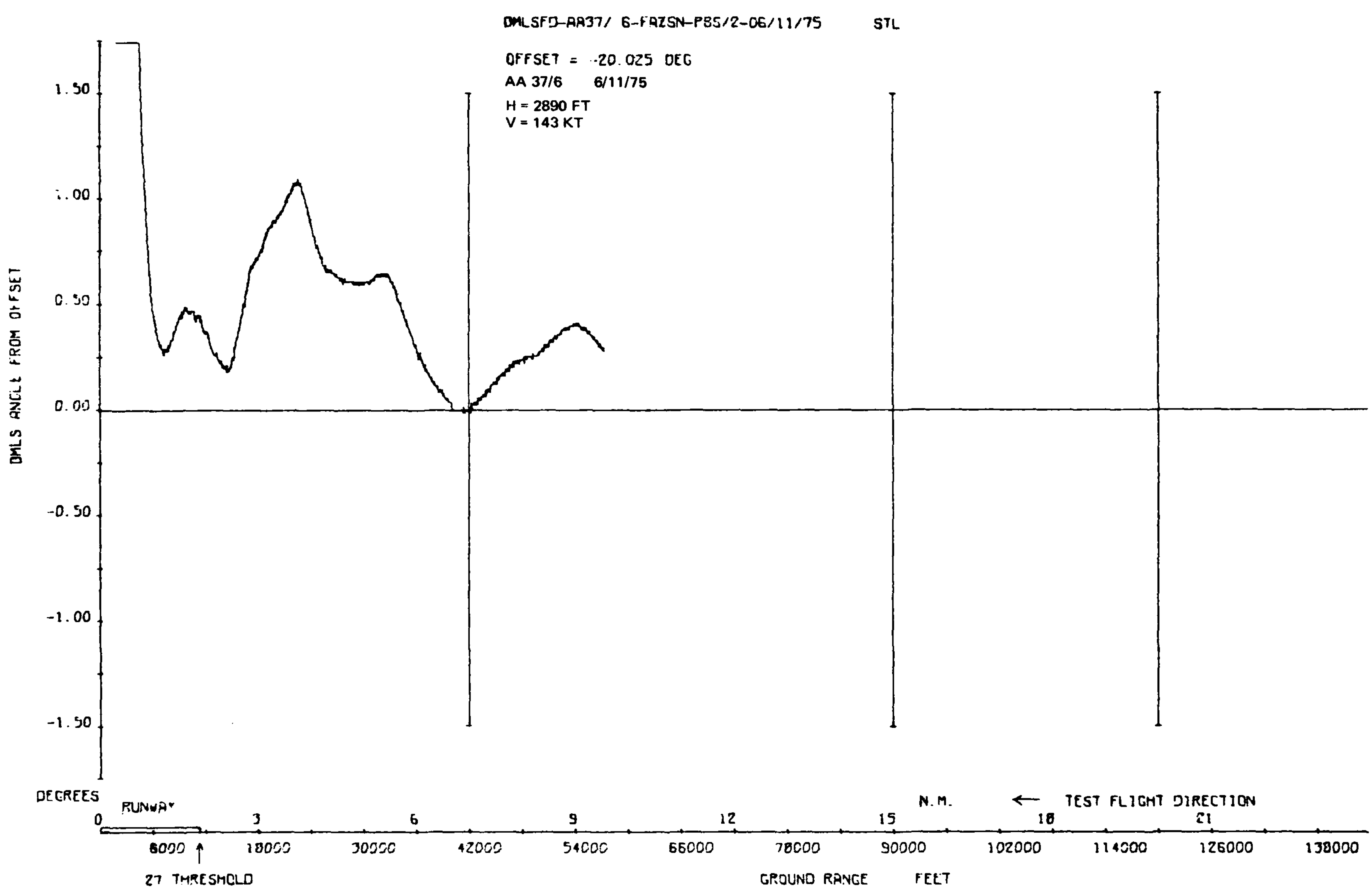



Fig 4.24b Approach azimuth radial at −20 degrees

Fig 4.24c

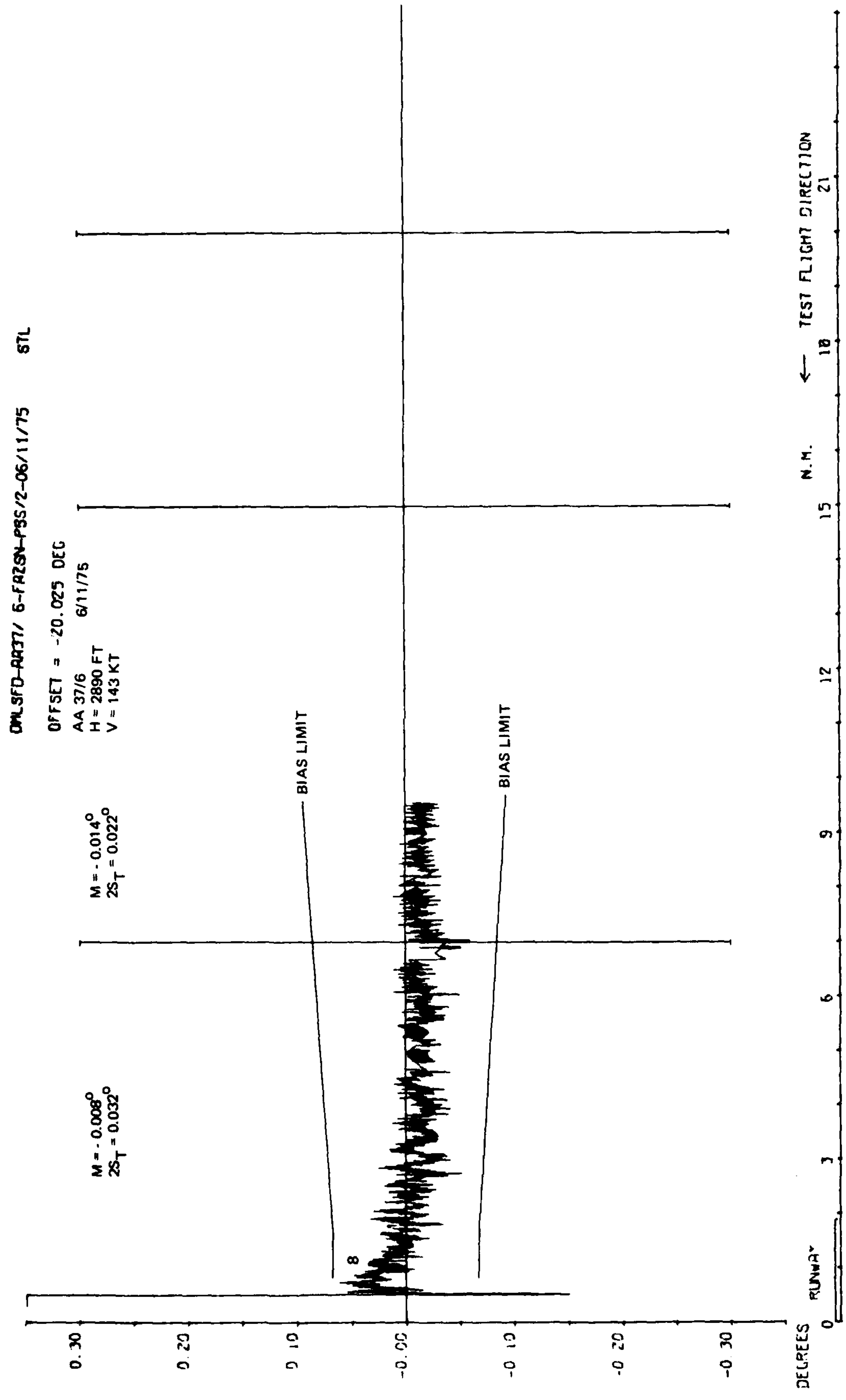



Fig 4.24c Approach azimuth radial at −20 degrees

TR 79052

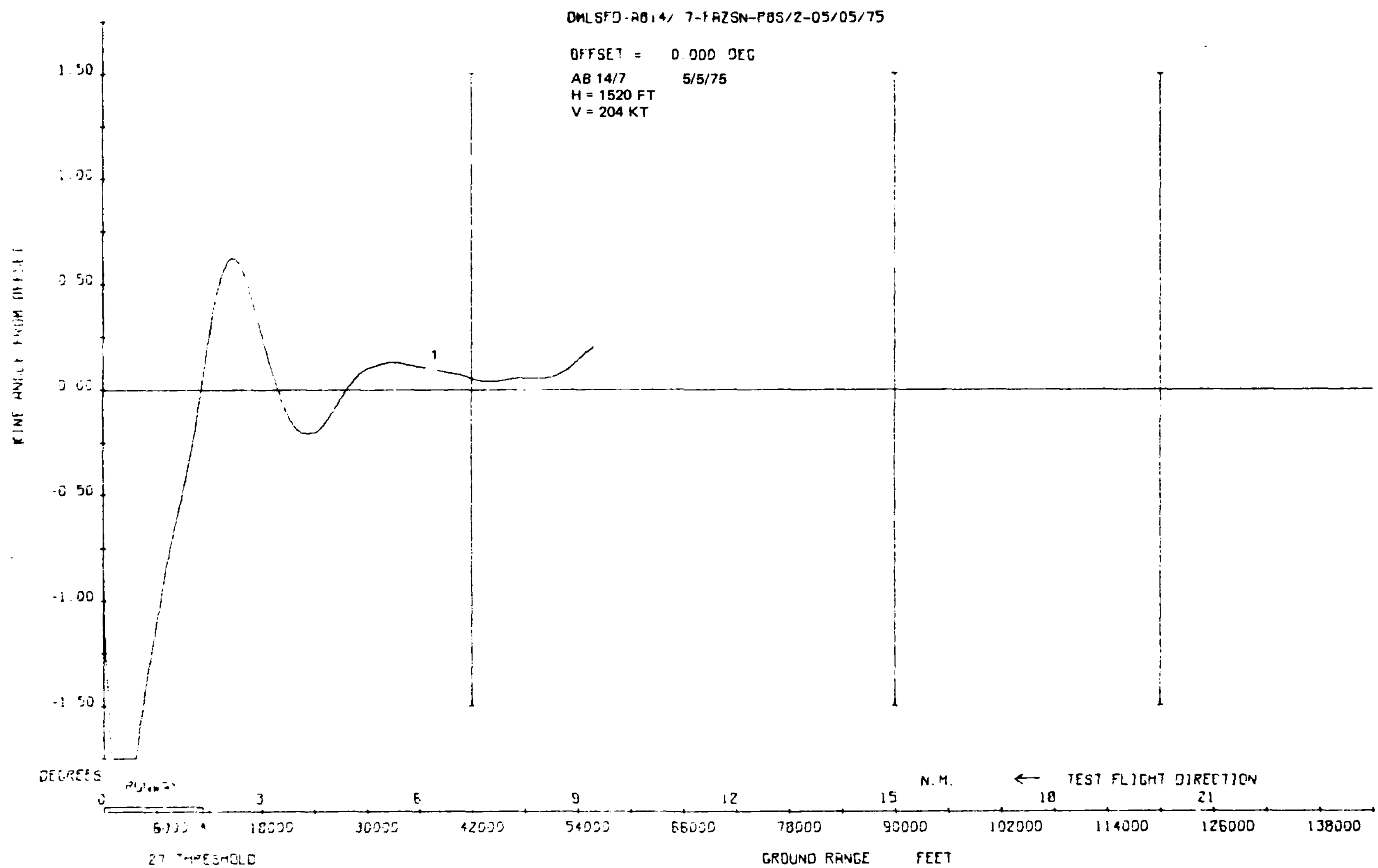



Fig 4.25a Approach azimuth radial at 0 degree

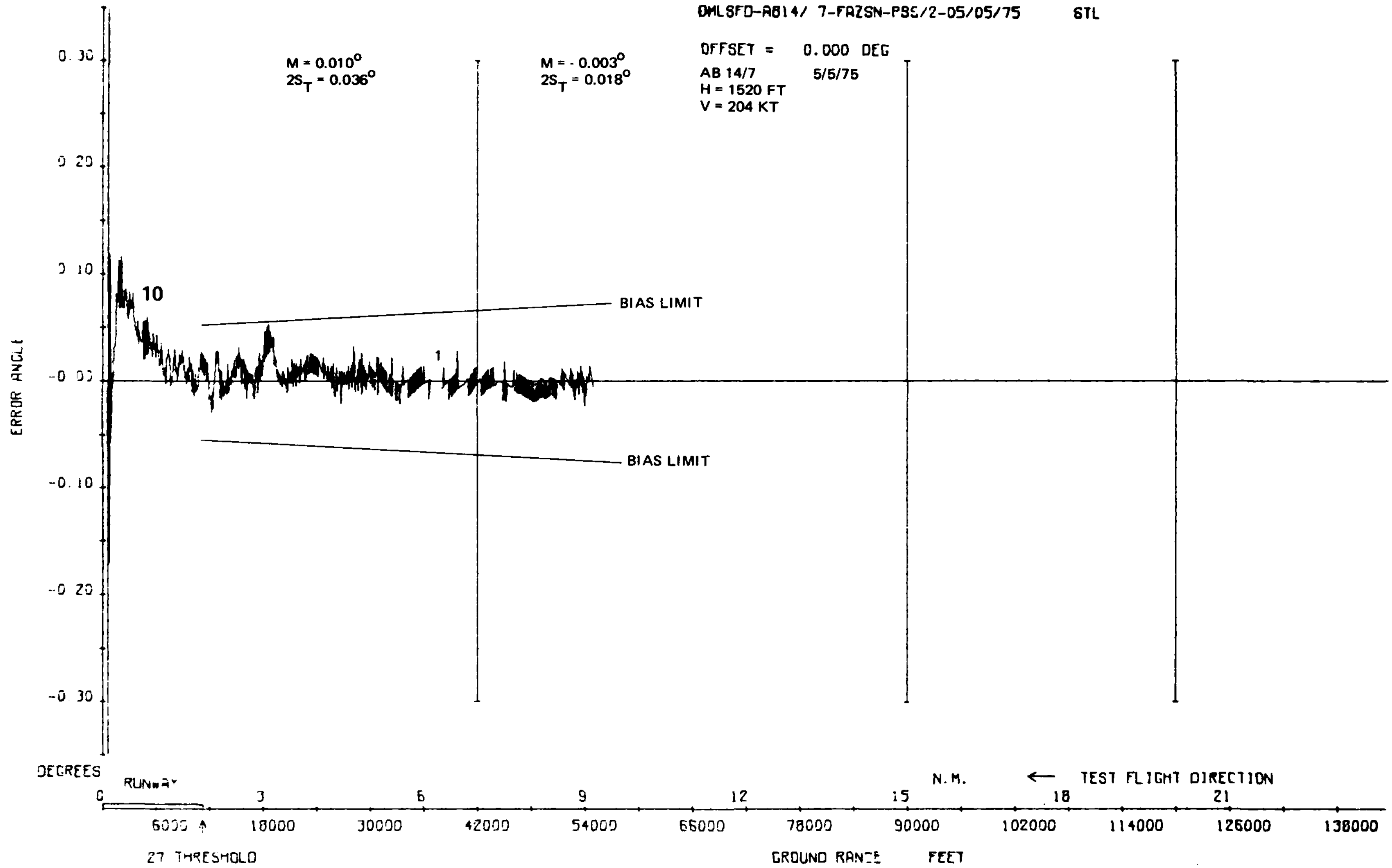



Fig 4.25c Approach azimuth radial at 0 degree

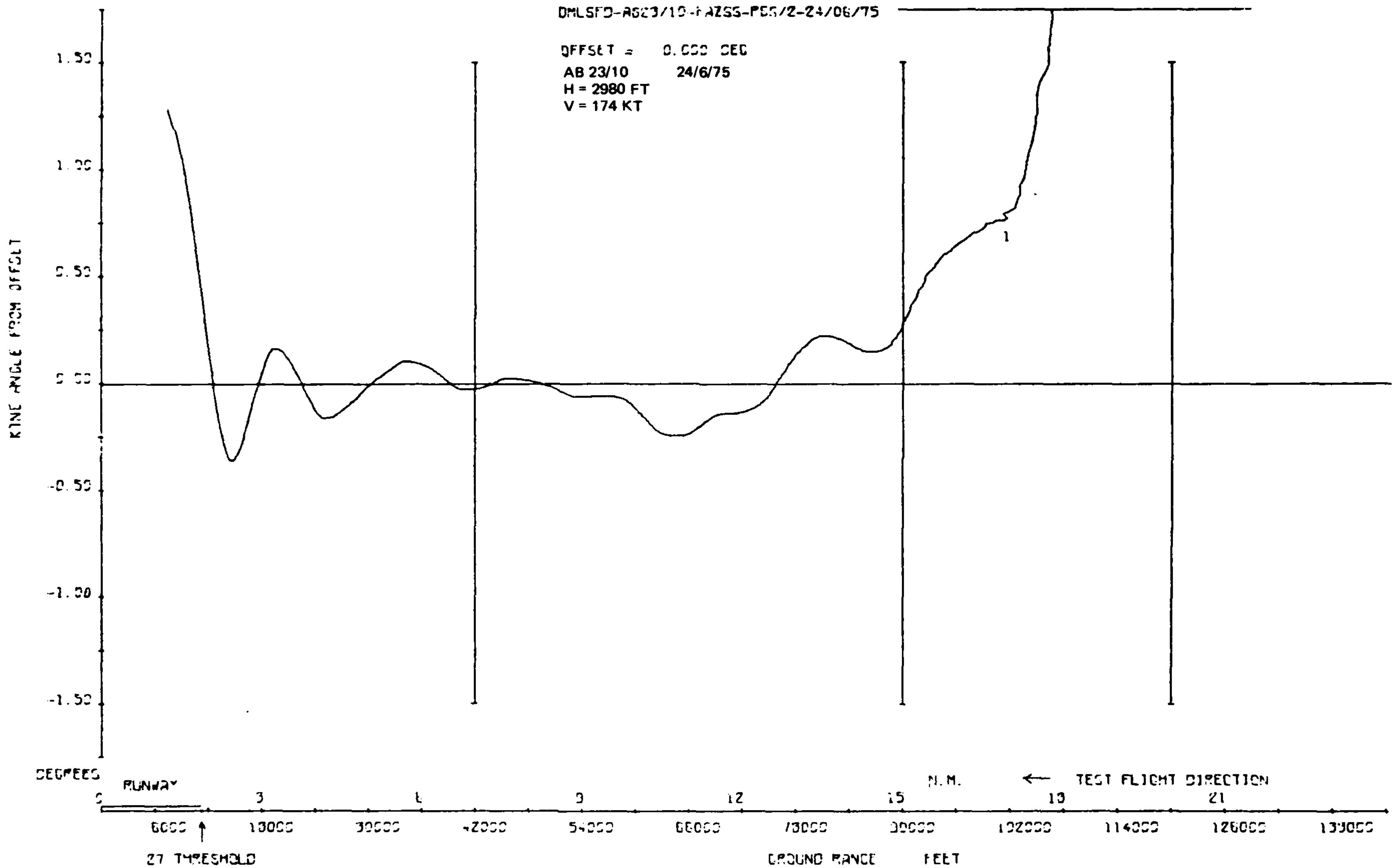



Fig 4.26a Approach azimuth radial at 0 degree

Fig 4.26b

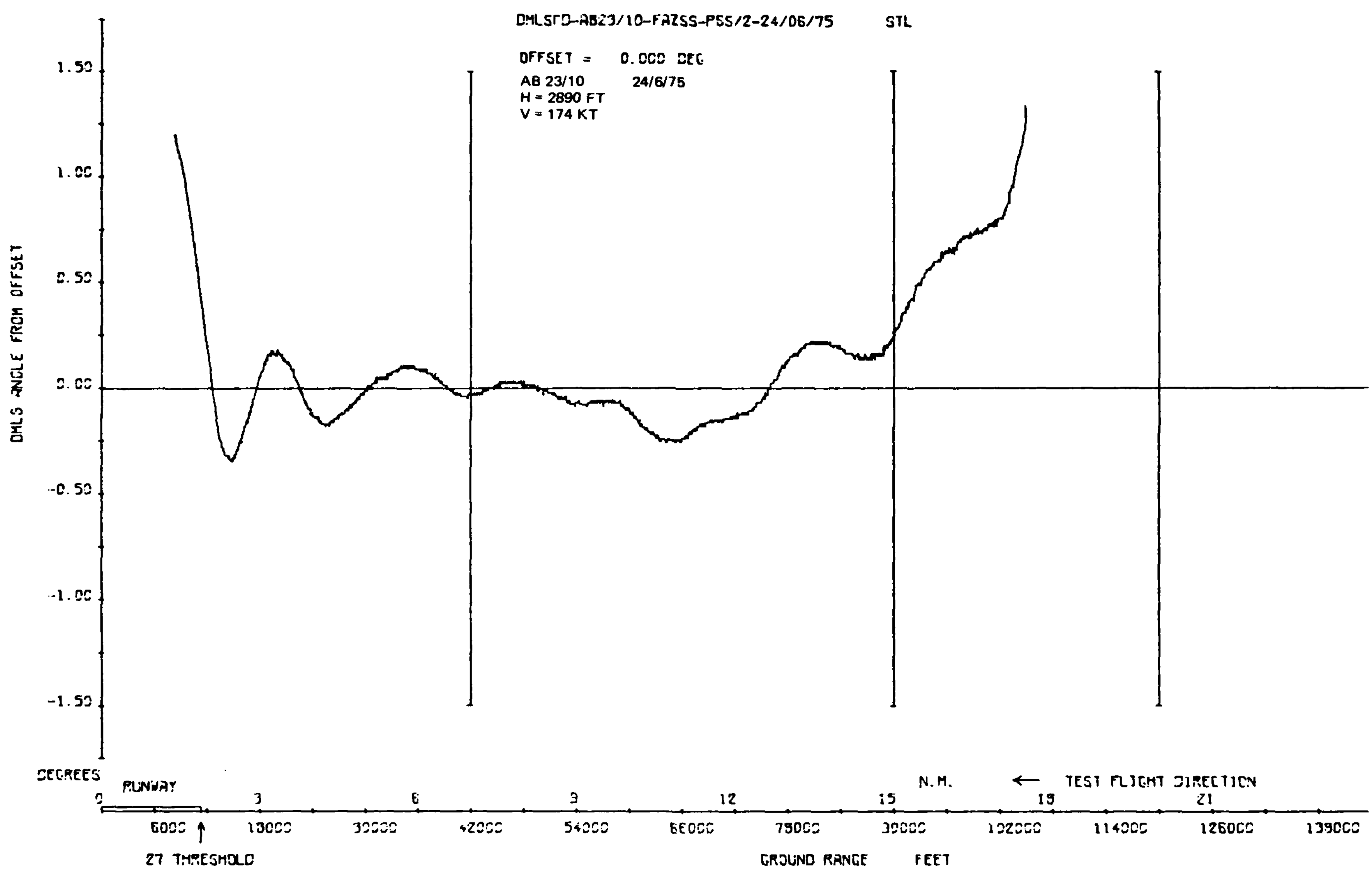



Fig 4.26b Approach azimuth radial at 0 degree

TR 79052

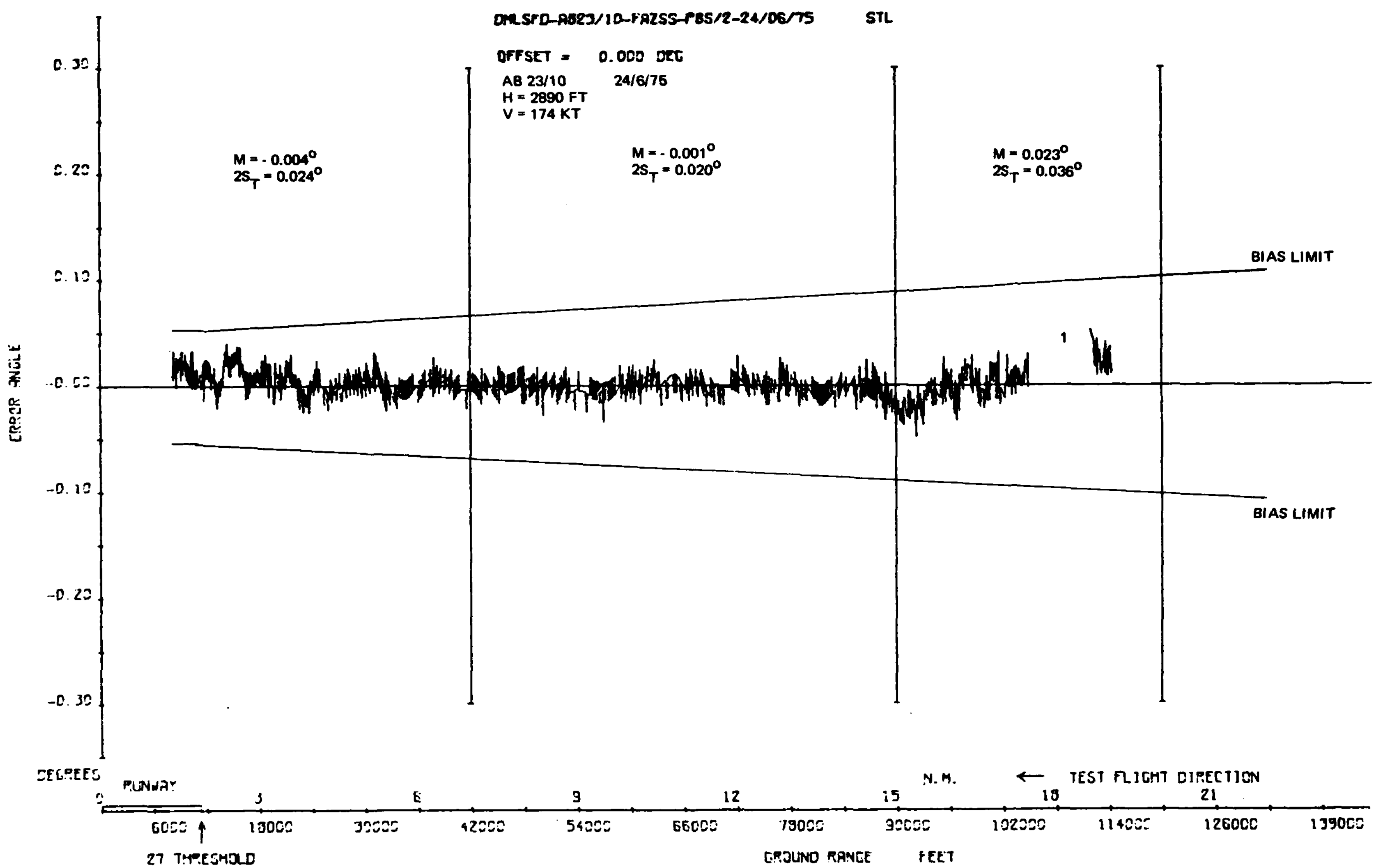



Fig 4.26c Approach azimuth radial at 0 degree

Fig 4.26c

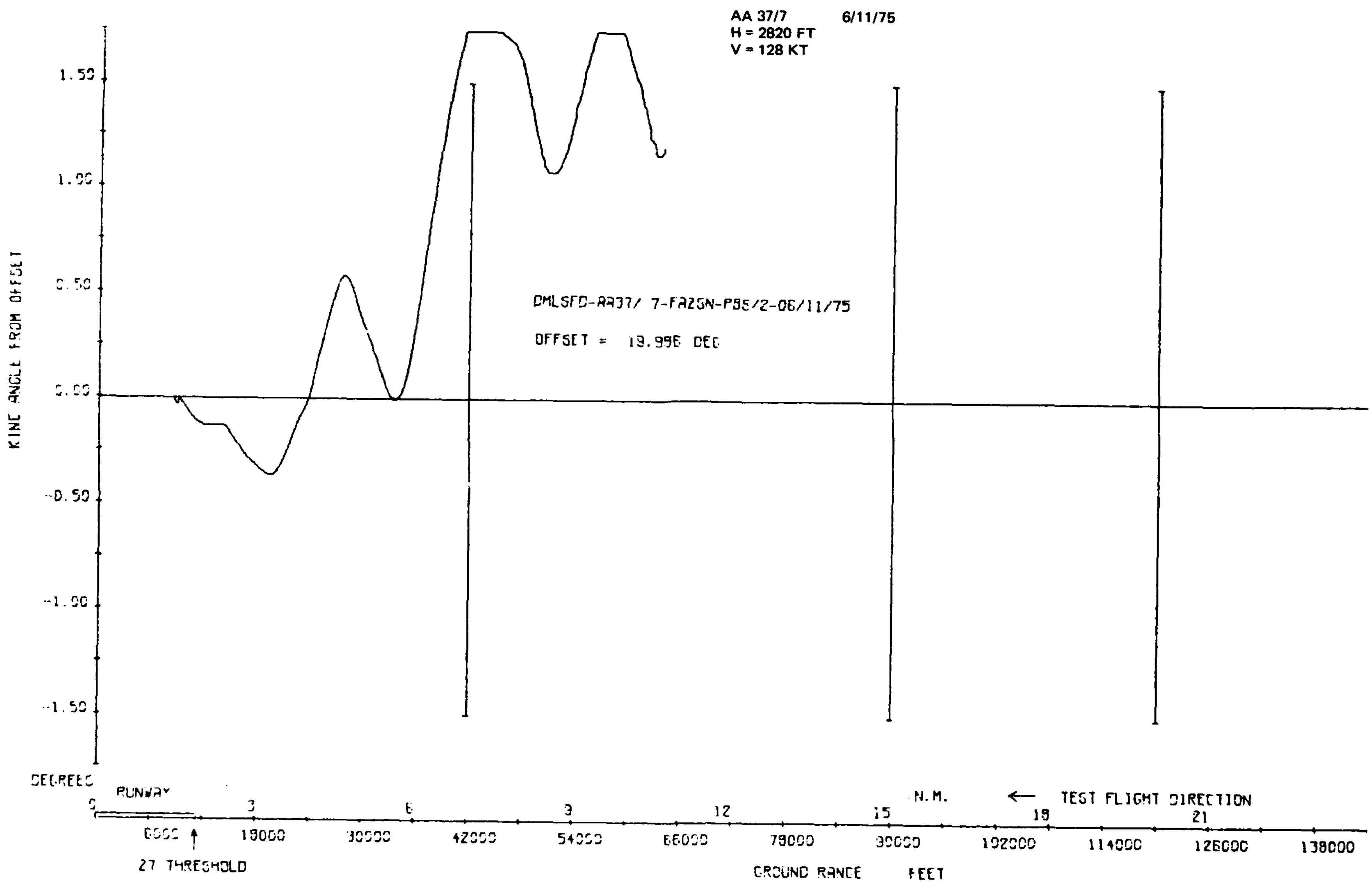



Fig 4.27a Approach azimuth radial at +20 degrees

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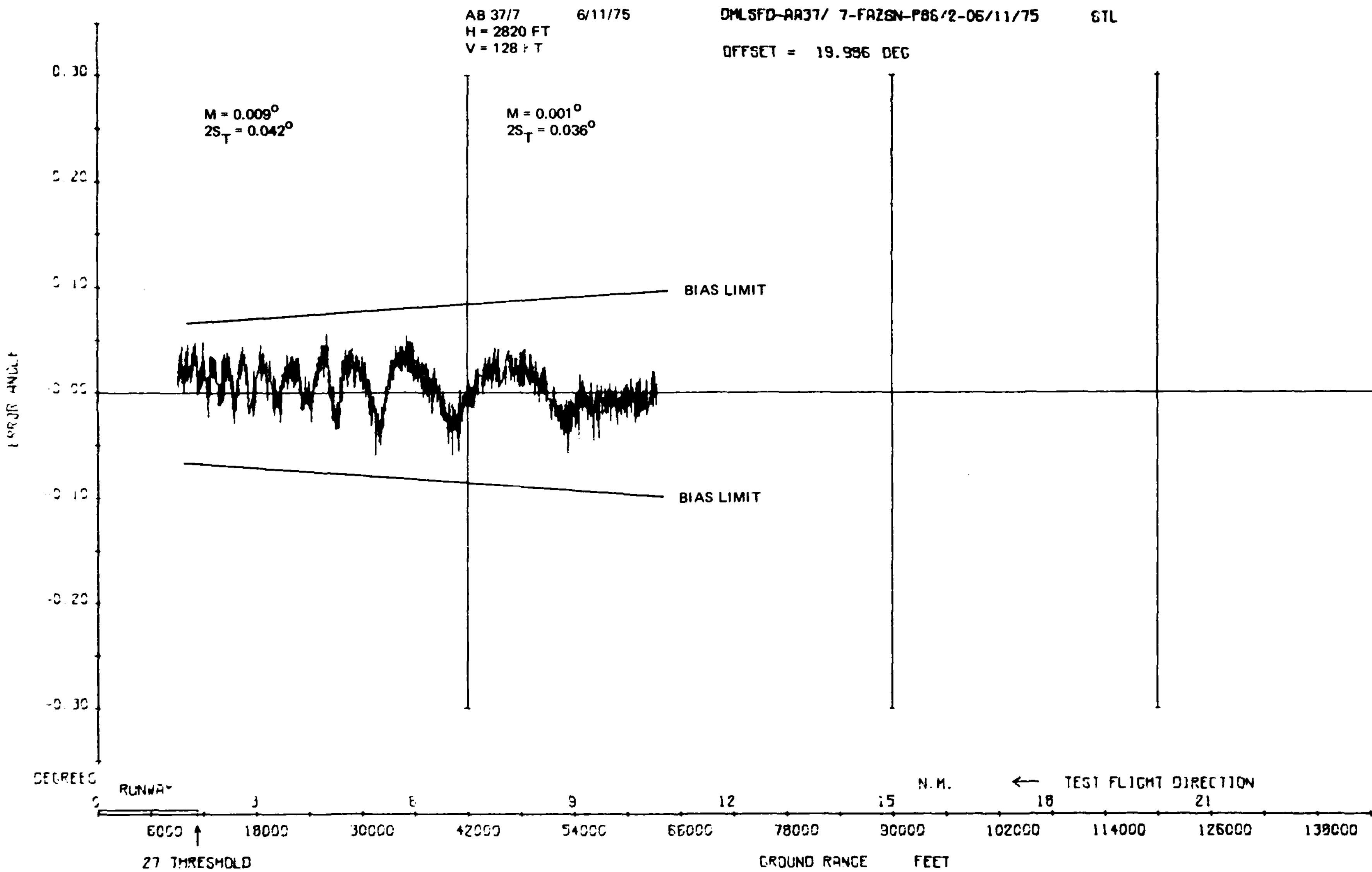


Fig 4.27c Approach azimuth radial at +20 degrees

Fig 4.27c

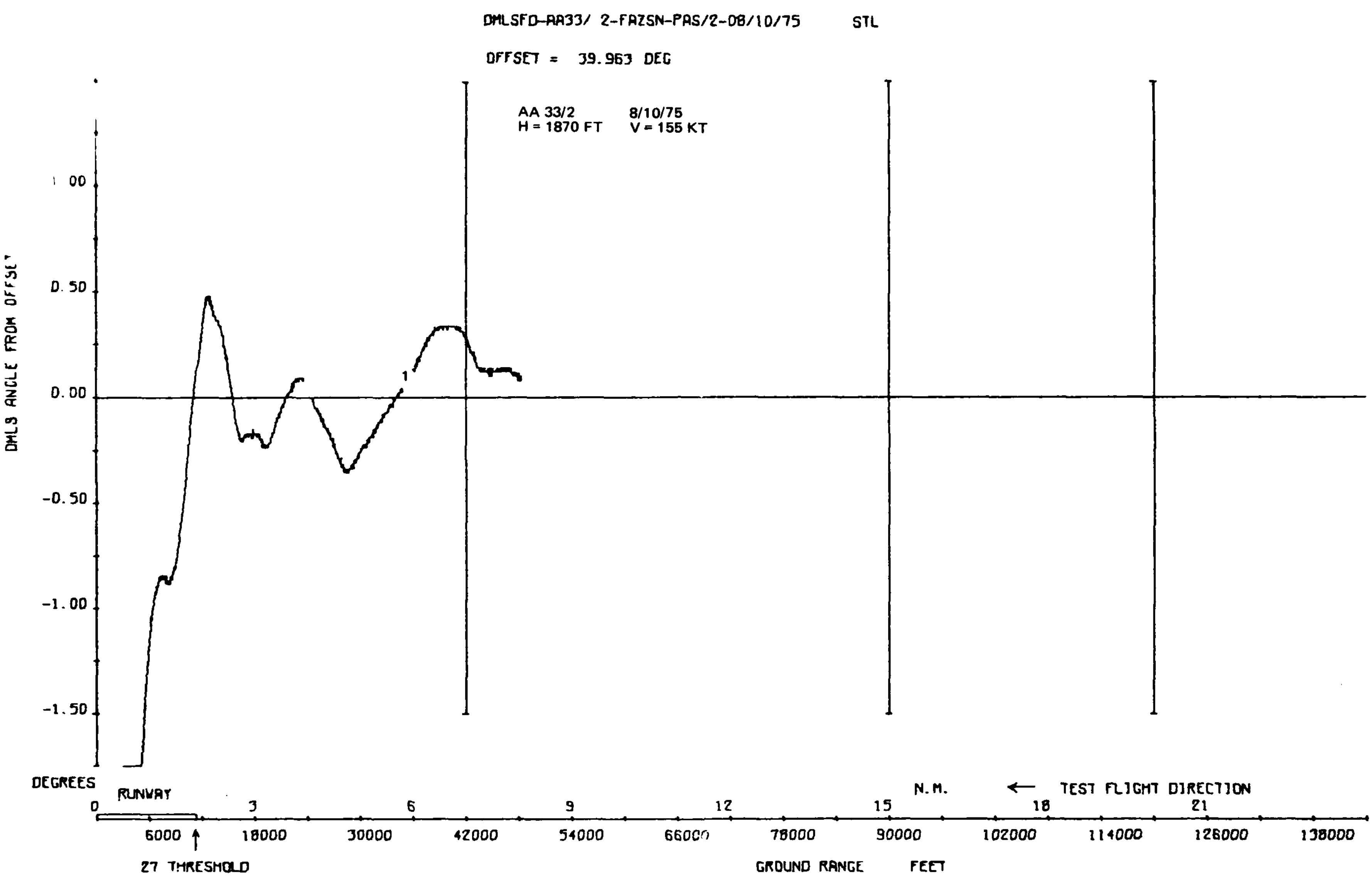


Fig 4.28b Approach azimuth radial at +40 degrees

TR 79052

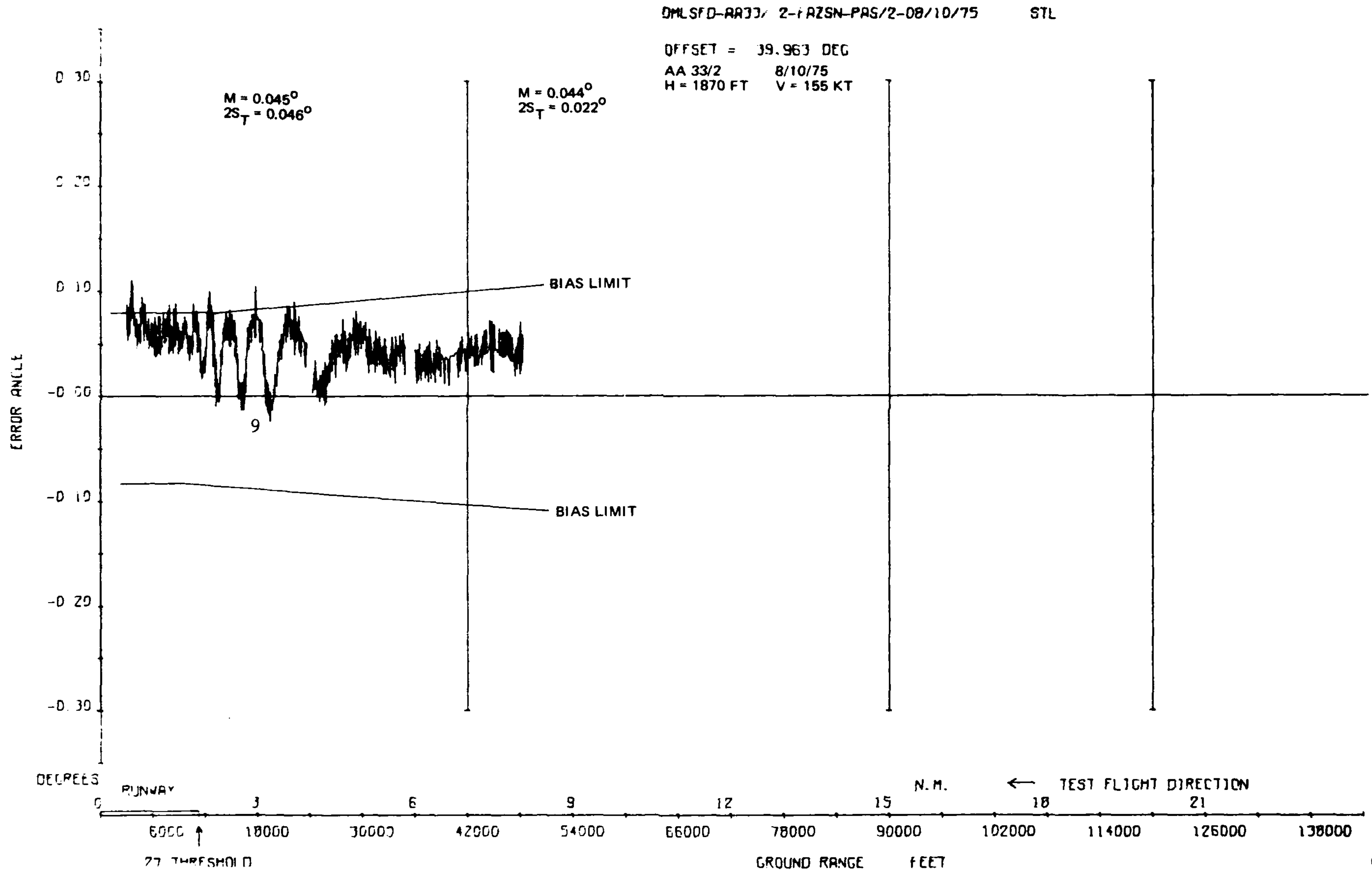


Fig 4.28c Approach azimuth radial at +40 degrees

Fig 4.28c

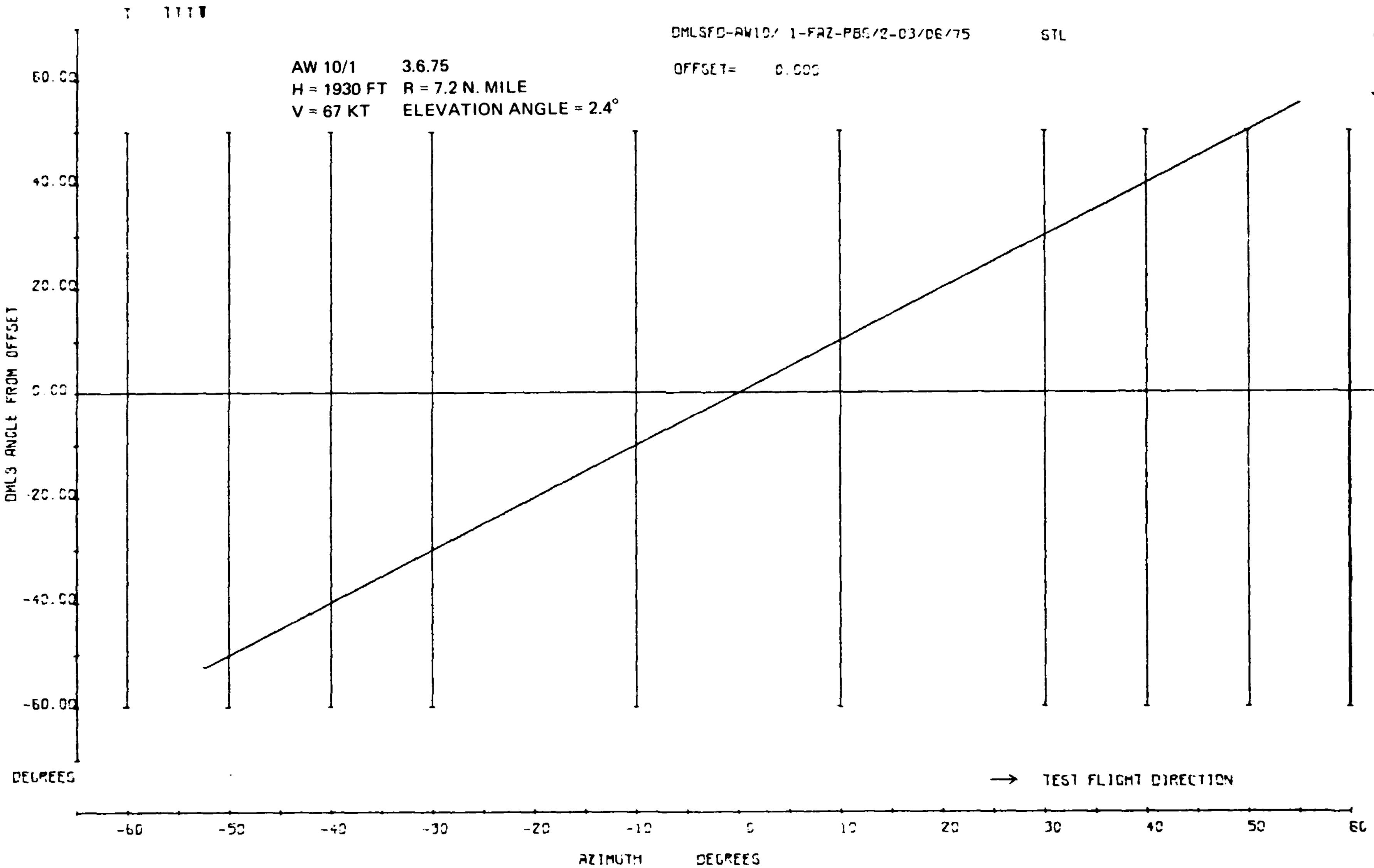


**Fig 4.29a/b Approach azimuth orbital flight**

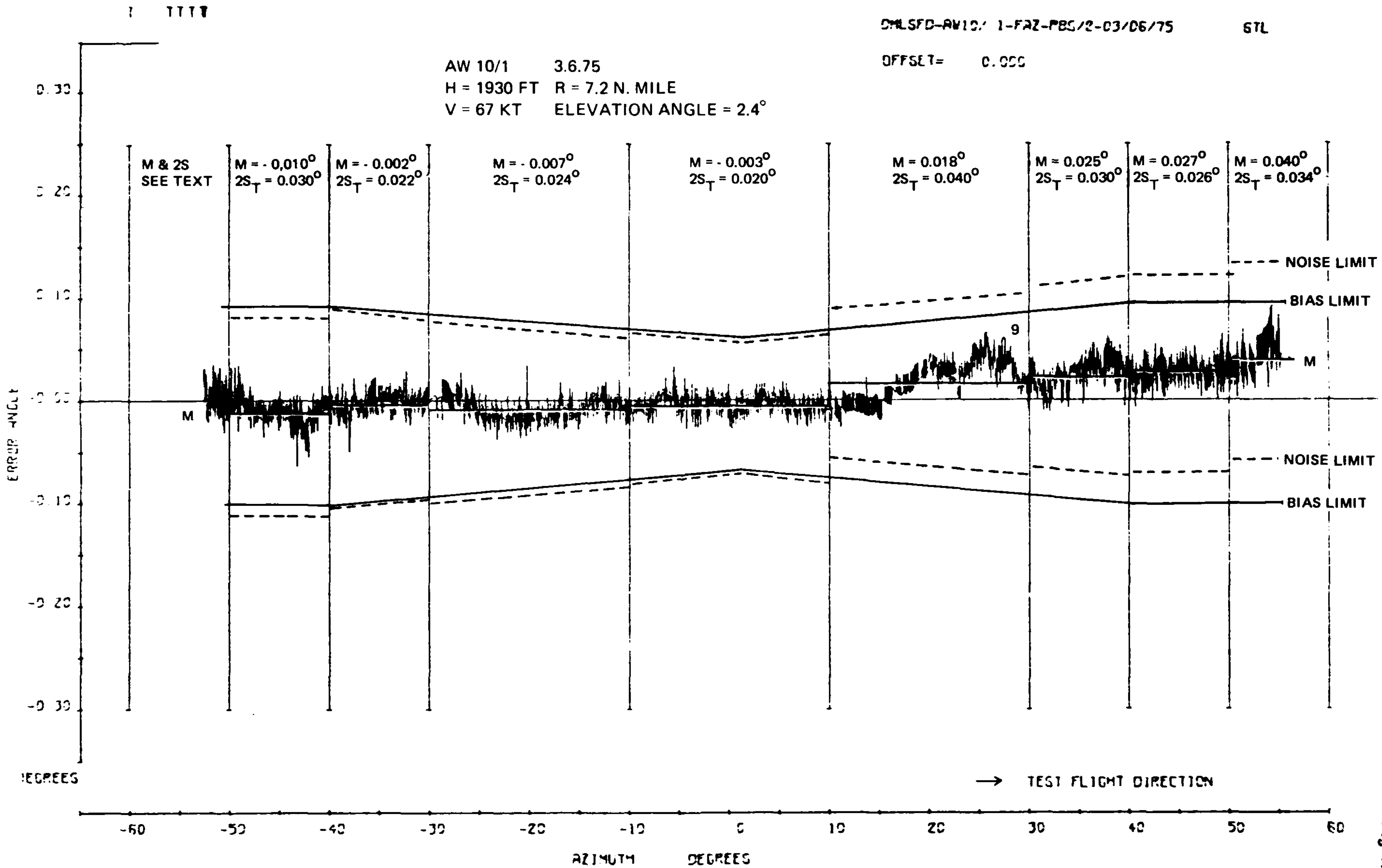


Fig 4.29c Approach azimuth orbital flight

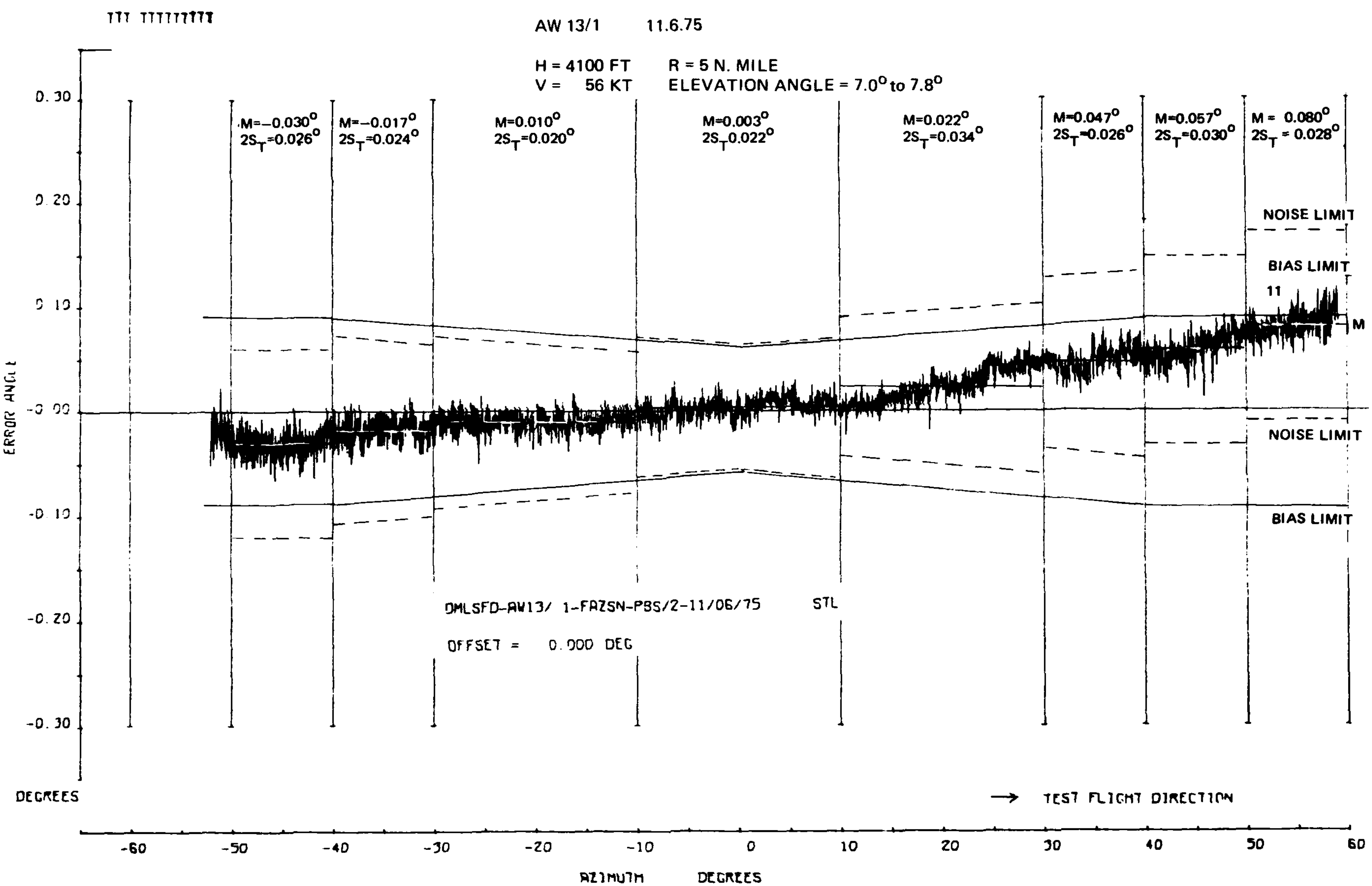


Fig 4.30c Approach azimuth orbital flight at 4100 ft. 5 n mile radius

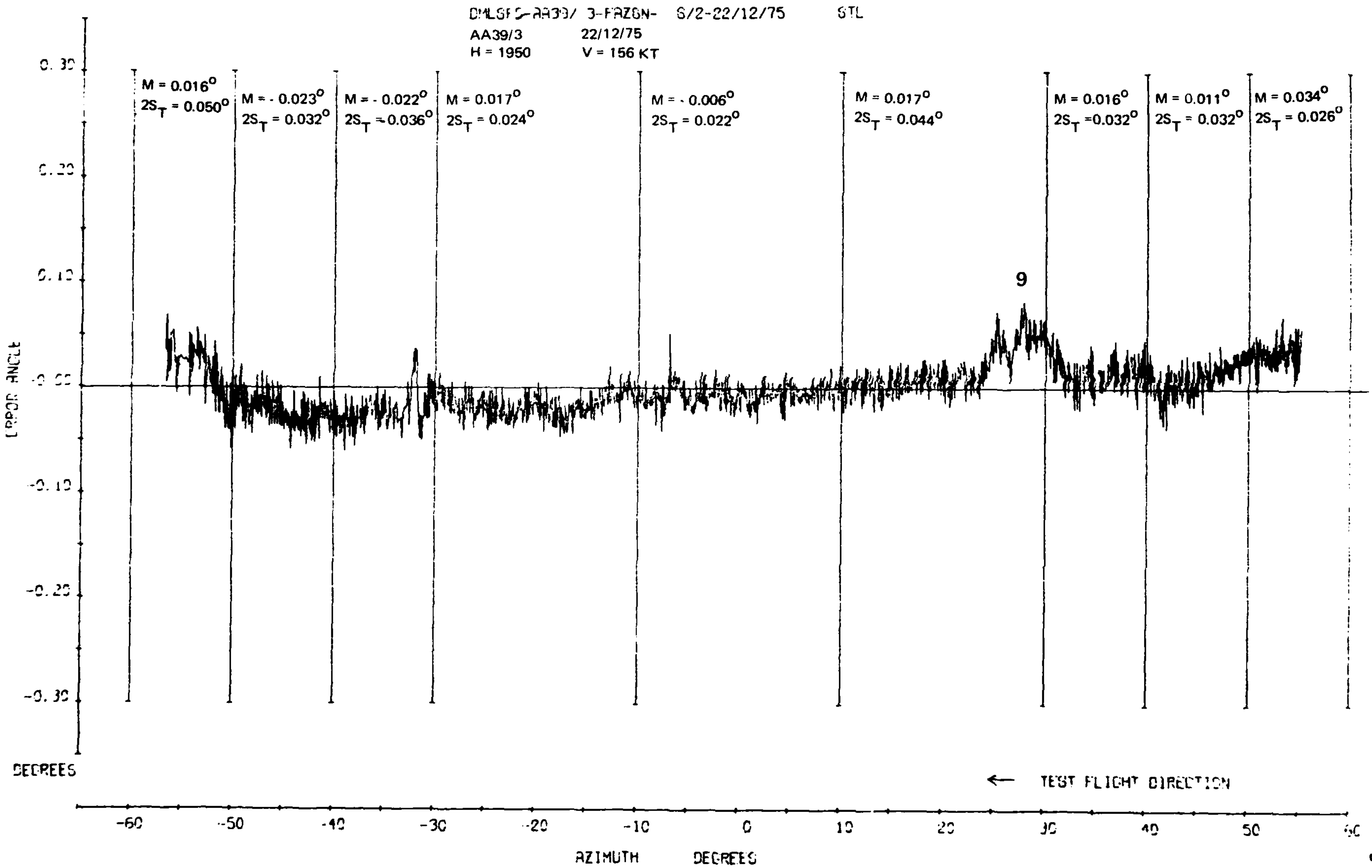


Fig 4.31c Approach azimuth orbital flight at 1950 ft. 6 n mile radius

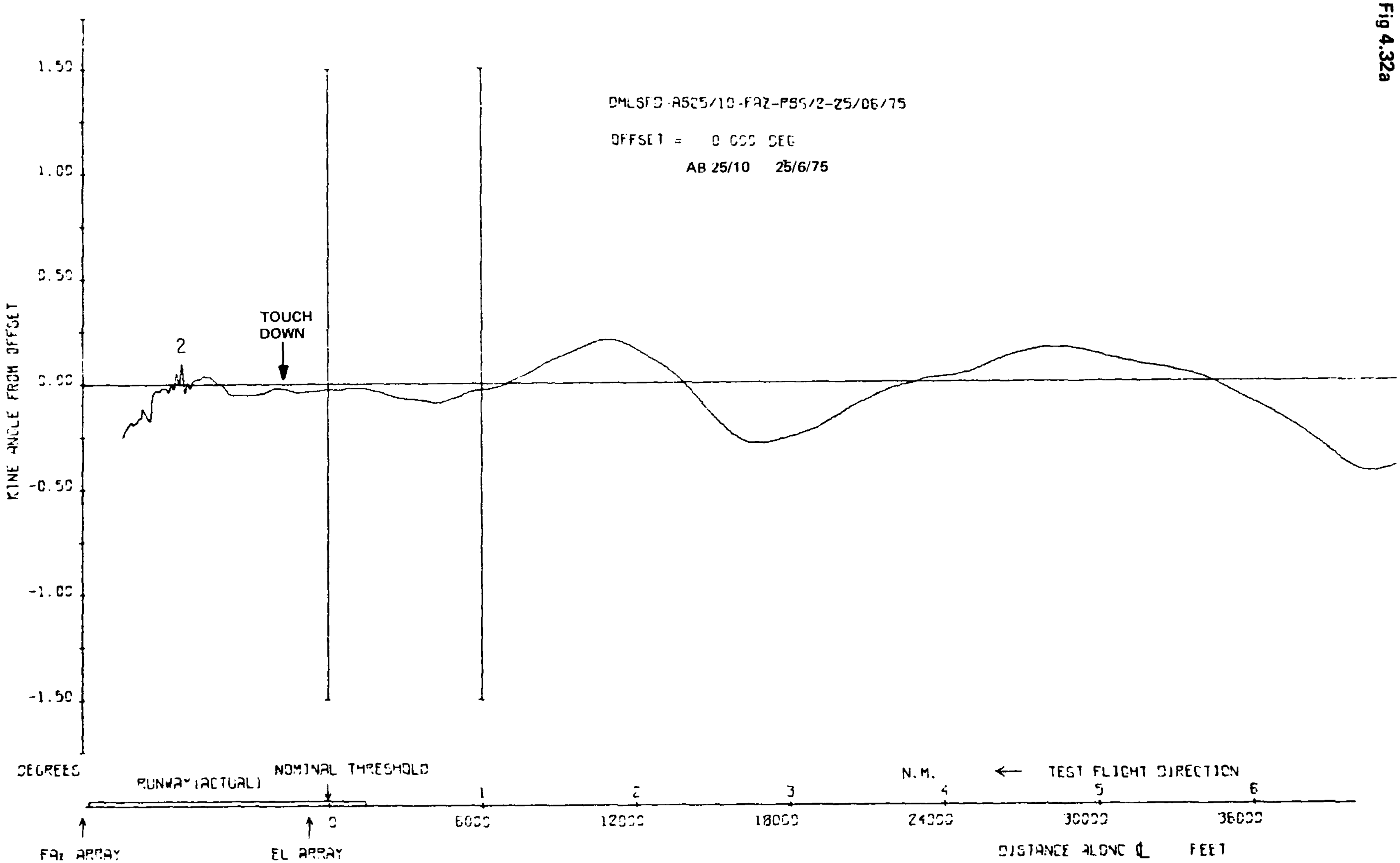


Fig 4.32a Approach azimuth accuracy. 3 degree approach to land and roll out

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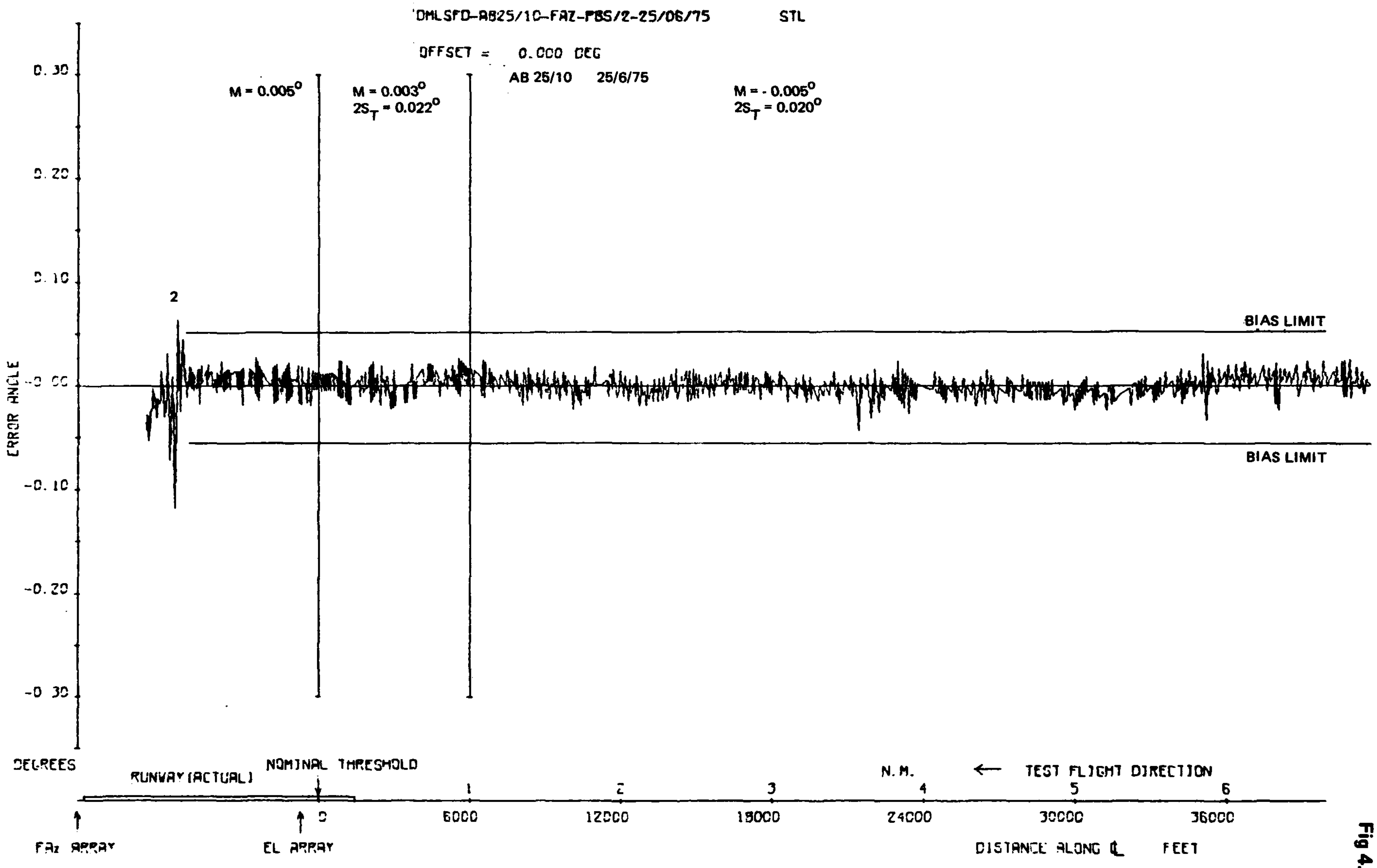


Fig 4.32c Approach azimuth accuracy. 3 degree approach to land and roll out

Fig 4.32c

Fig 4.33a

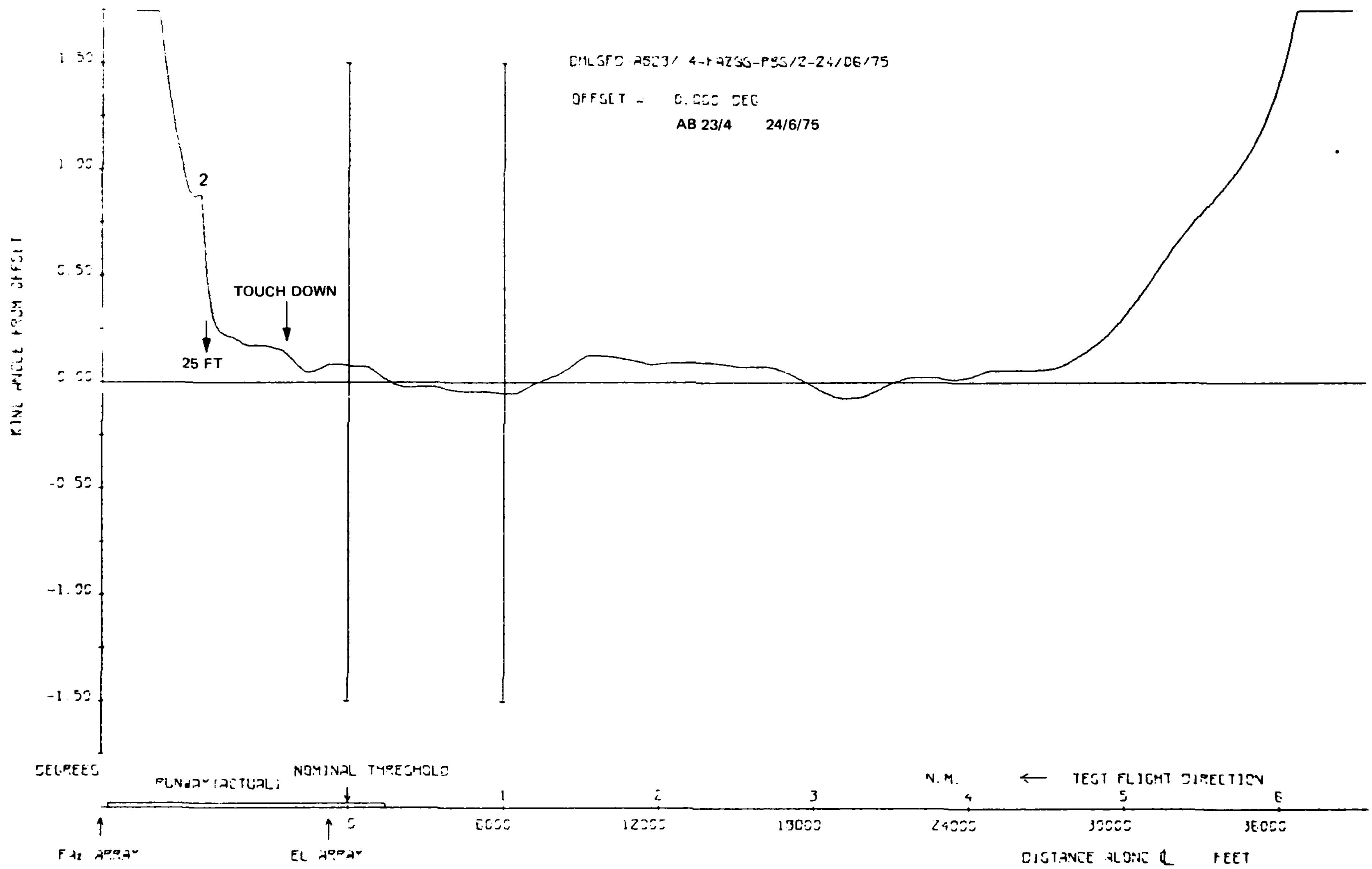


Fig 4.33a Approach azimuth accuracy. 3 degree approach to touch and go

TR 79052

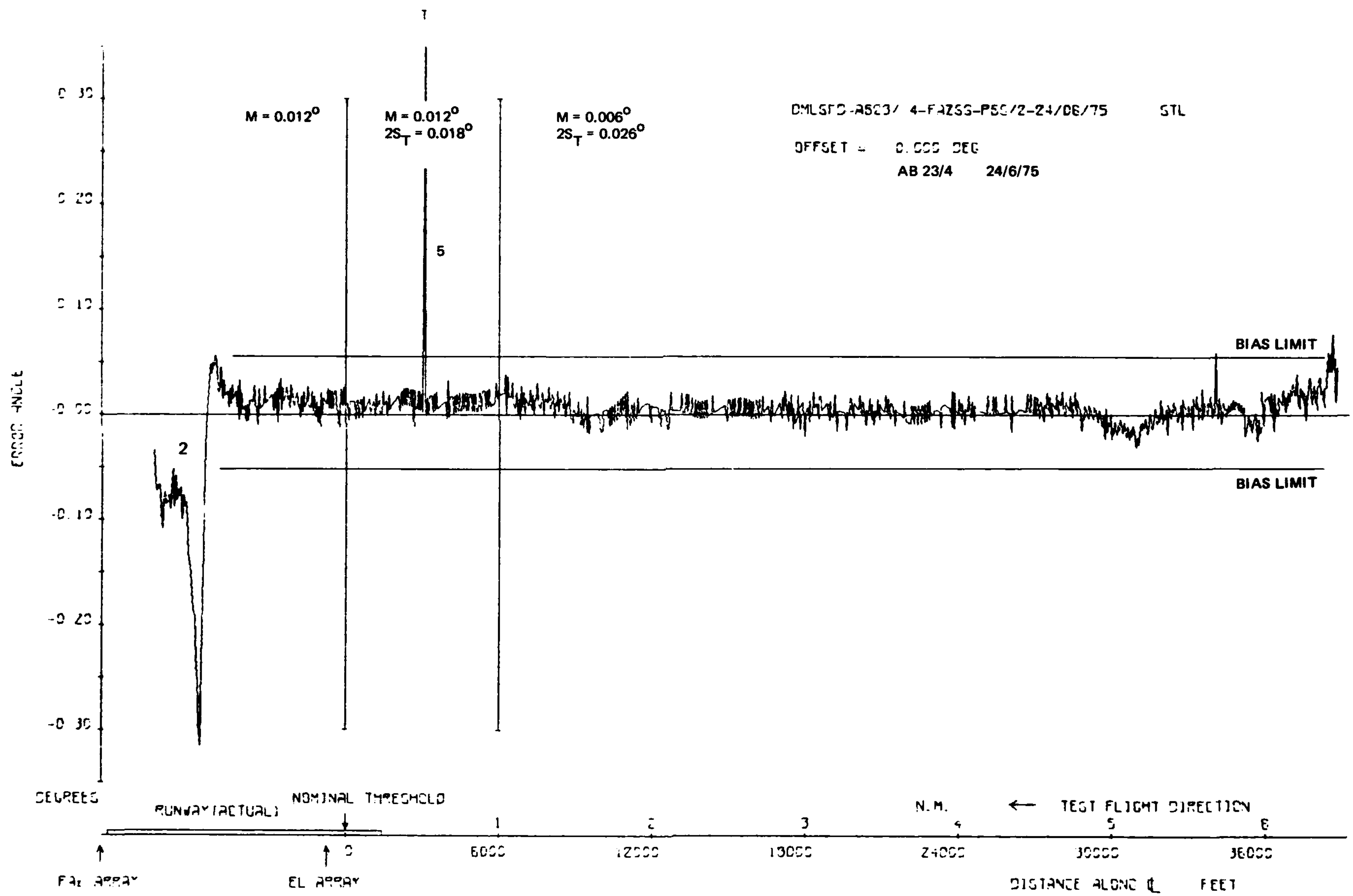


Fig 4.33c Approach azimuth accuracy. 3 degree approach to touch and go

Fig 4.34a

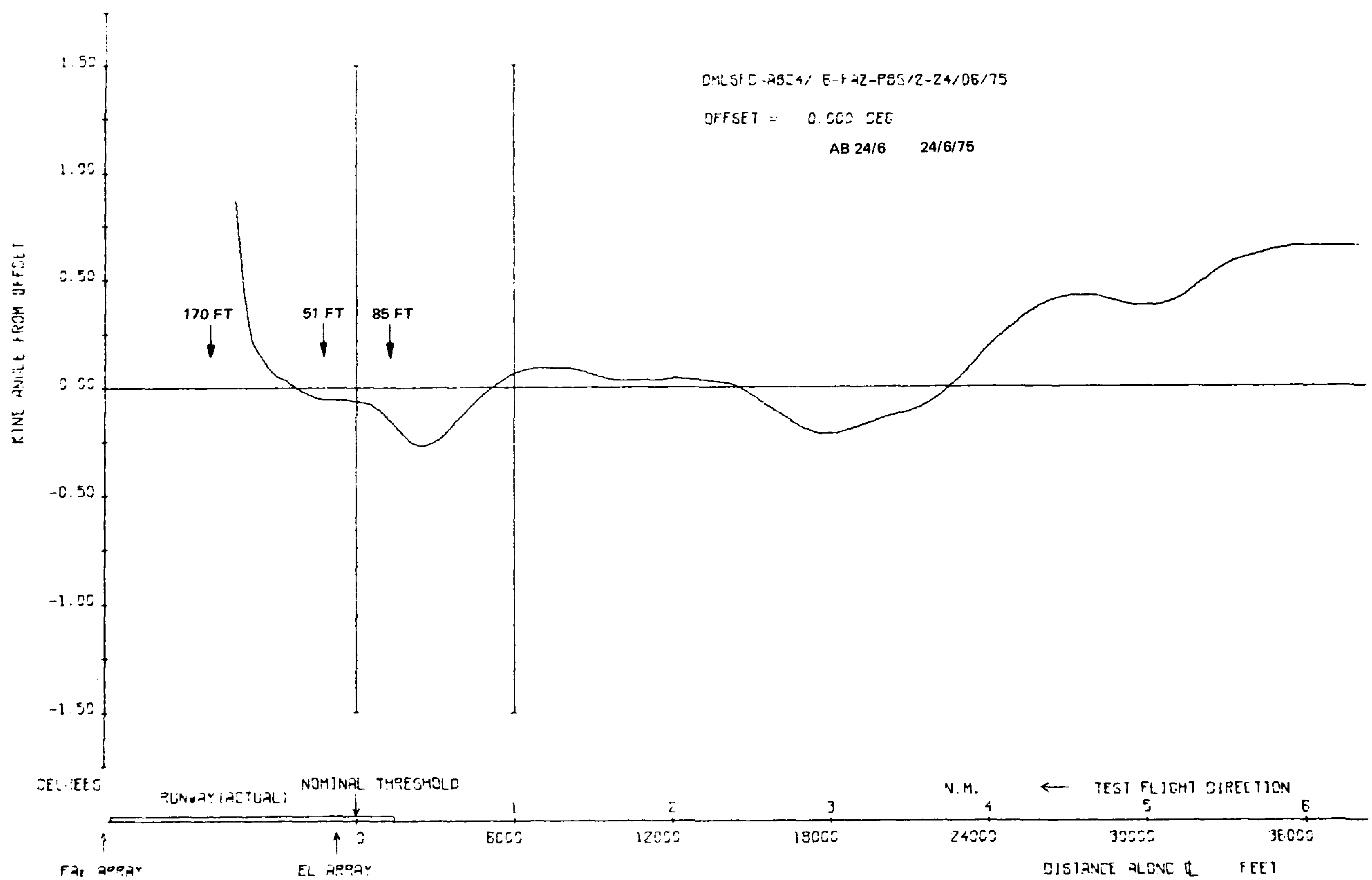


Fig 4.34a Approach azimuth accuracy. 3 degree approach to low overfly

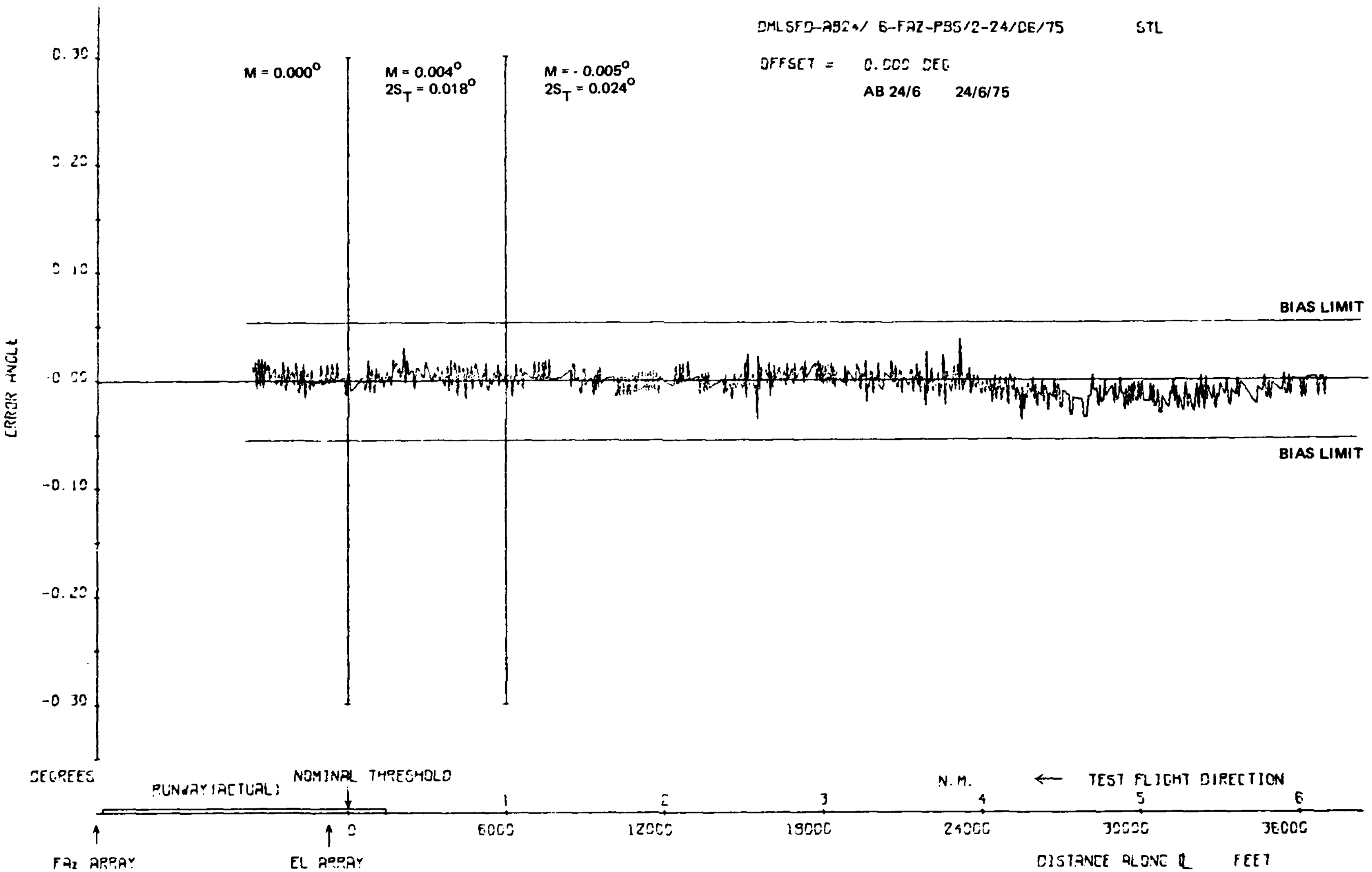


Fig 4.34c Approach azimuth accuracy. 3 degree approach to low overfly

Fig 4.35a

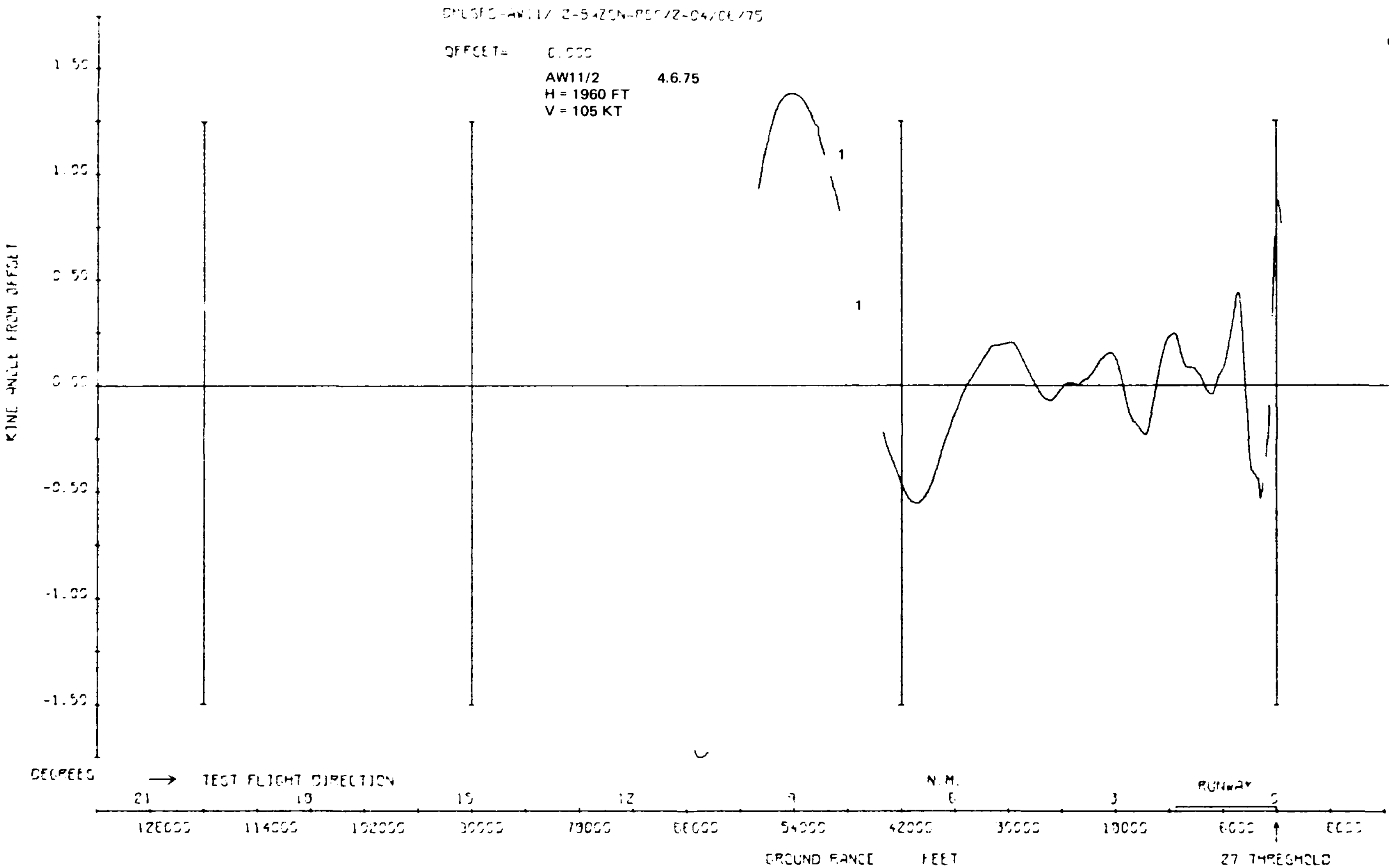


Fig 4.35a Missed approach azimuth radial flight on centre line

TR 79052

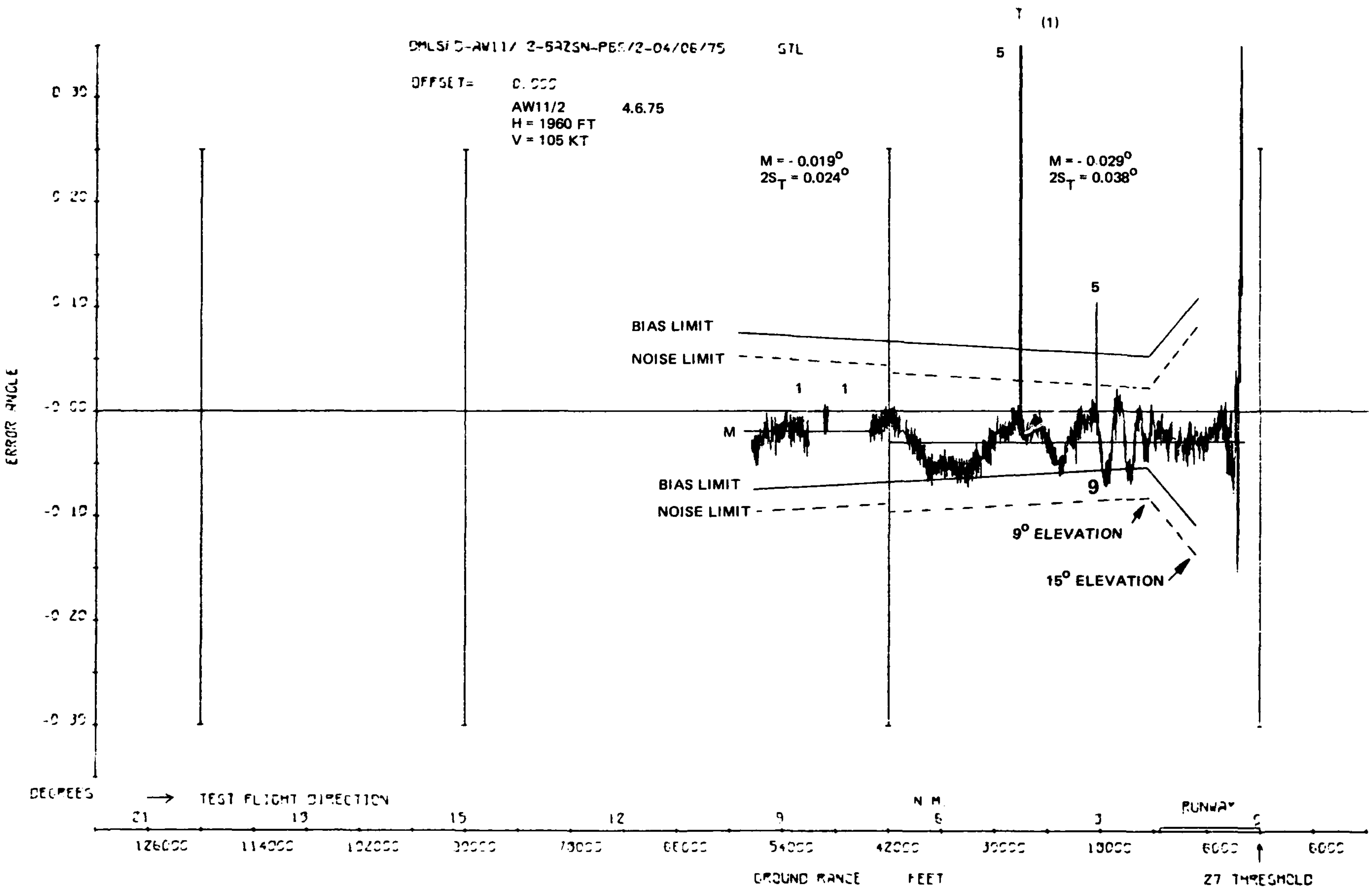


Fig 4.35c Missed approach azimuth radial flight on centre line

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CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND D--ETC(U)
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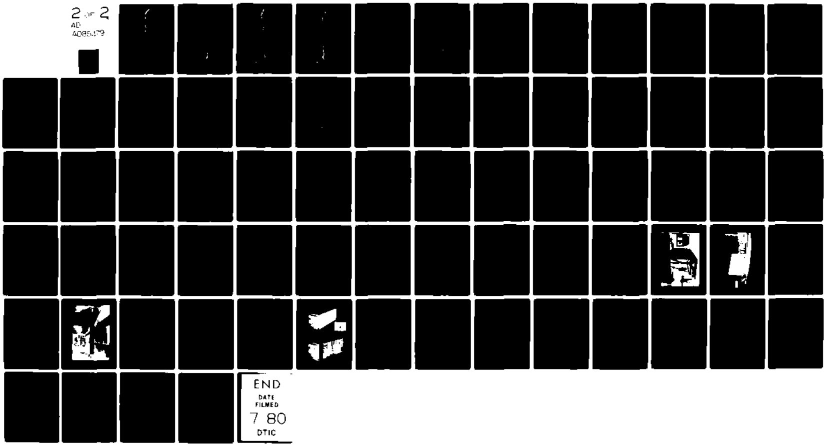

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Fig 4.36c

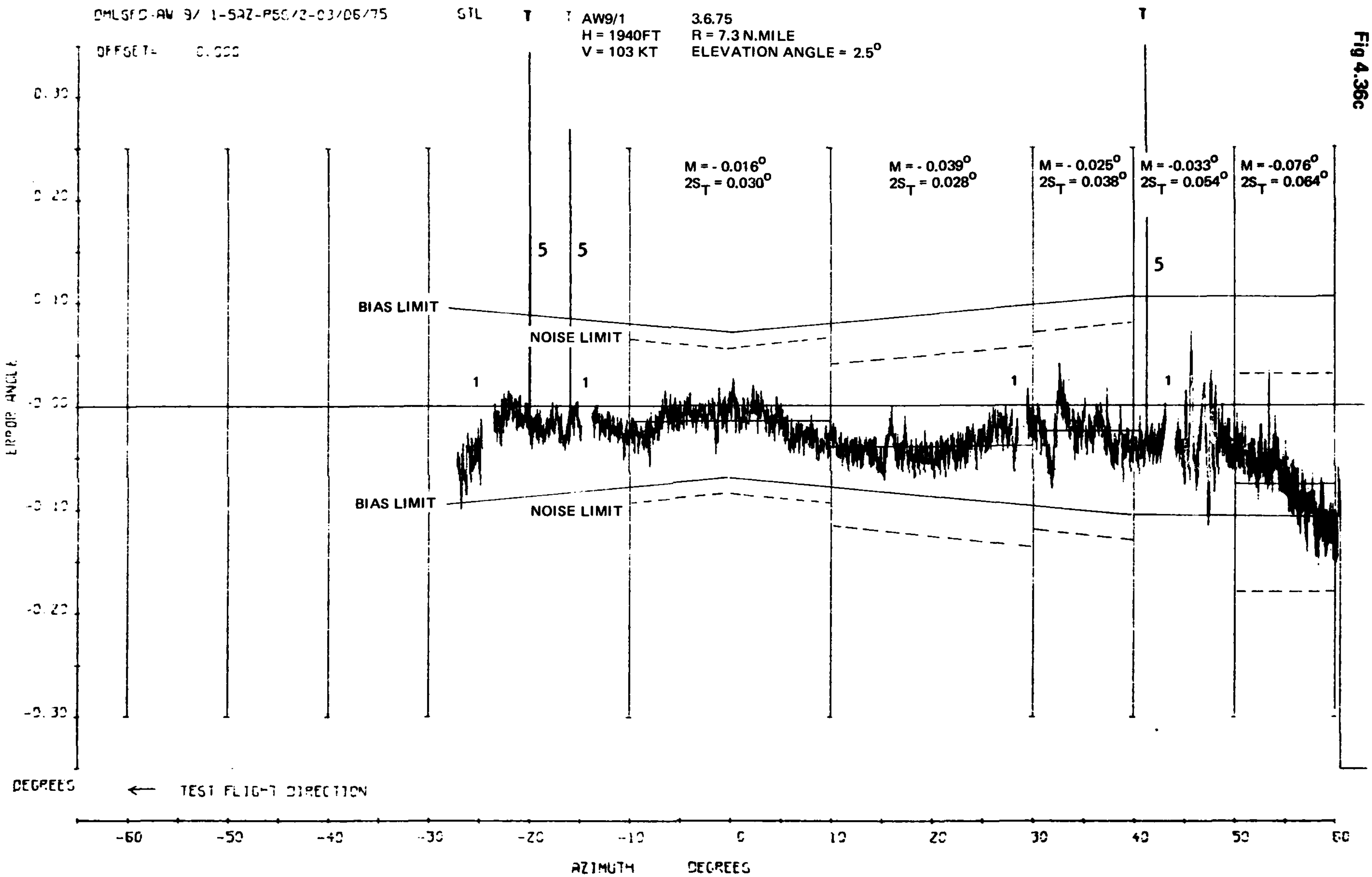


Fig 4.36c Missed approach azimuth orbital flight at 1940 ft and 7.3 n mile radius

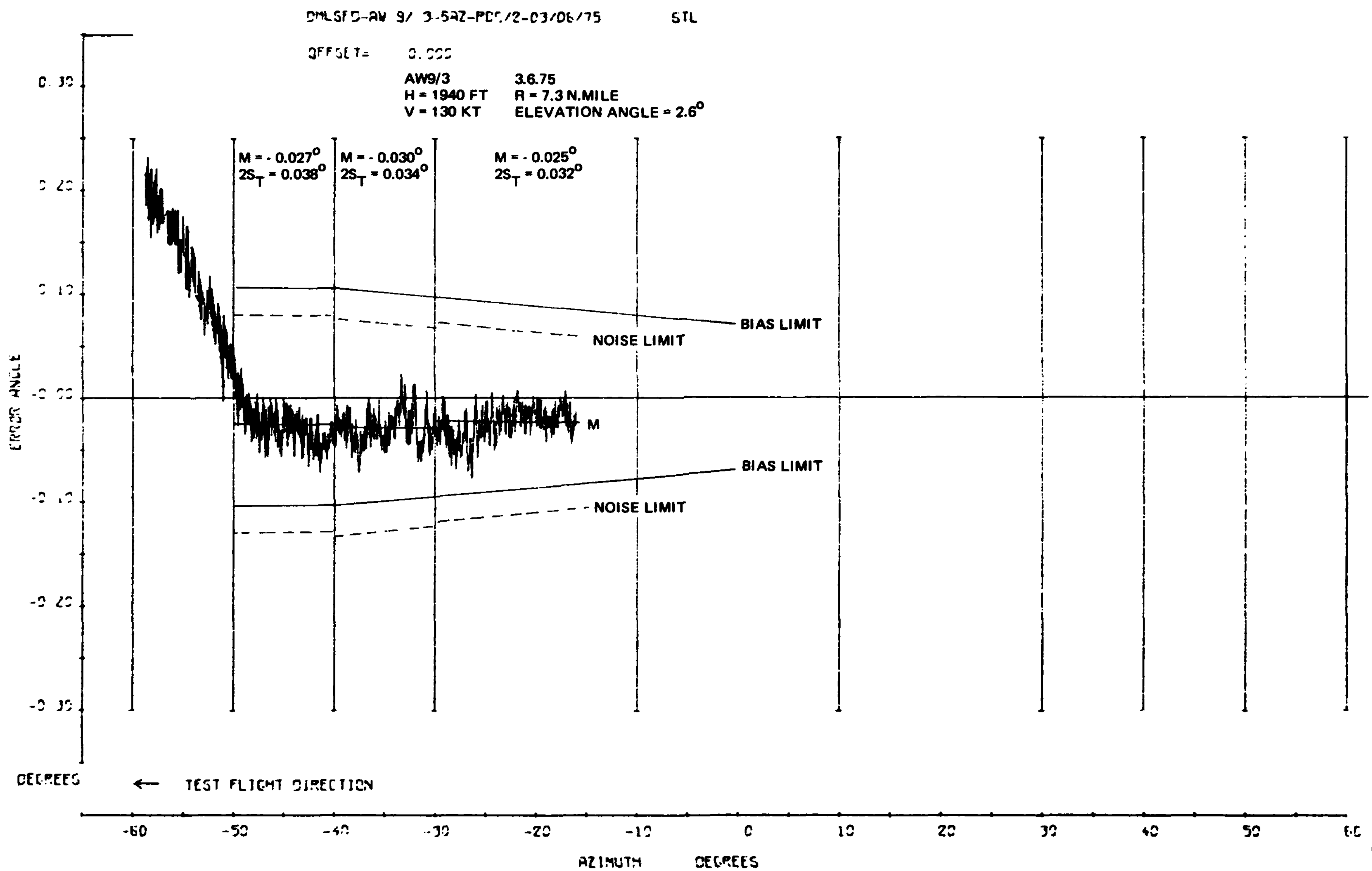


Fig 4.37c Missed approach orbital flight at 1940 ft and 7.3 n mile radius

Fig 4.38c

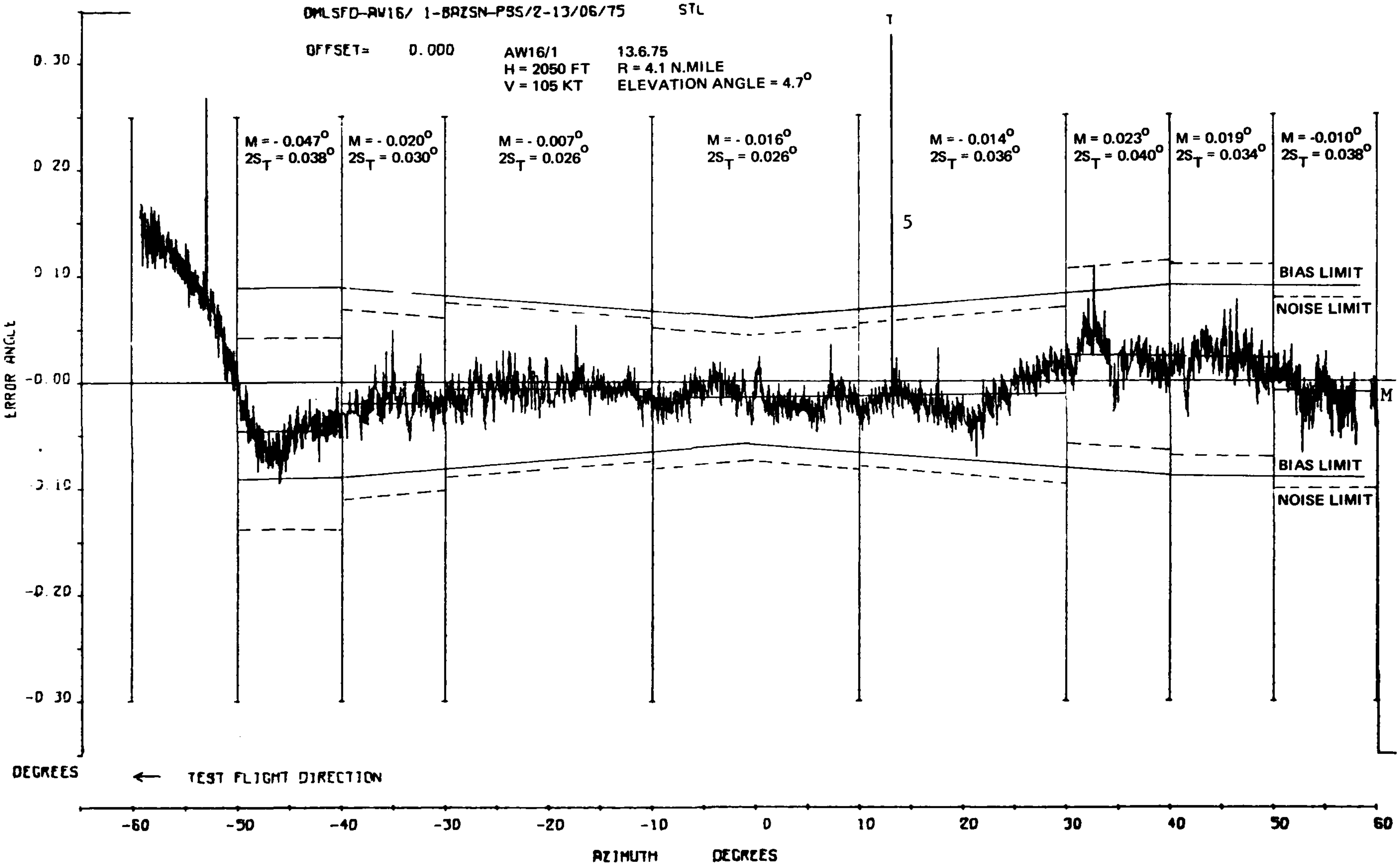


Fig 4.38c Missed approach orbital flight at 2050 ft and 4.1 n mile radius

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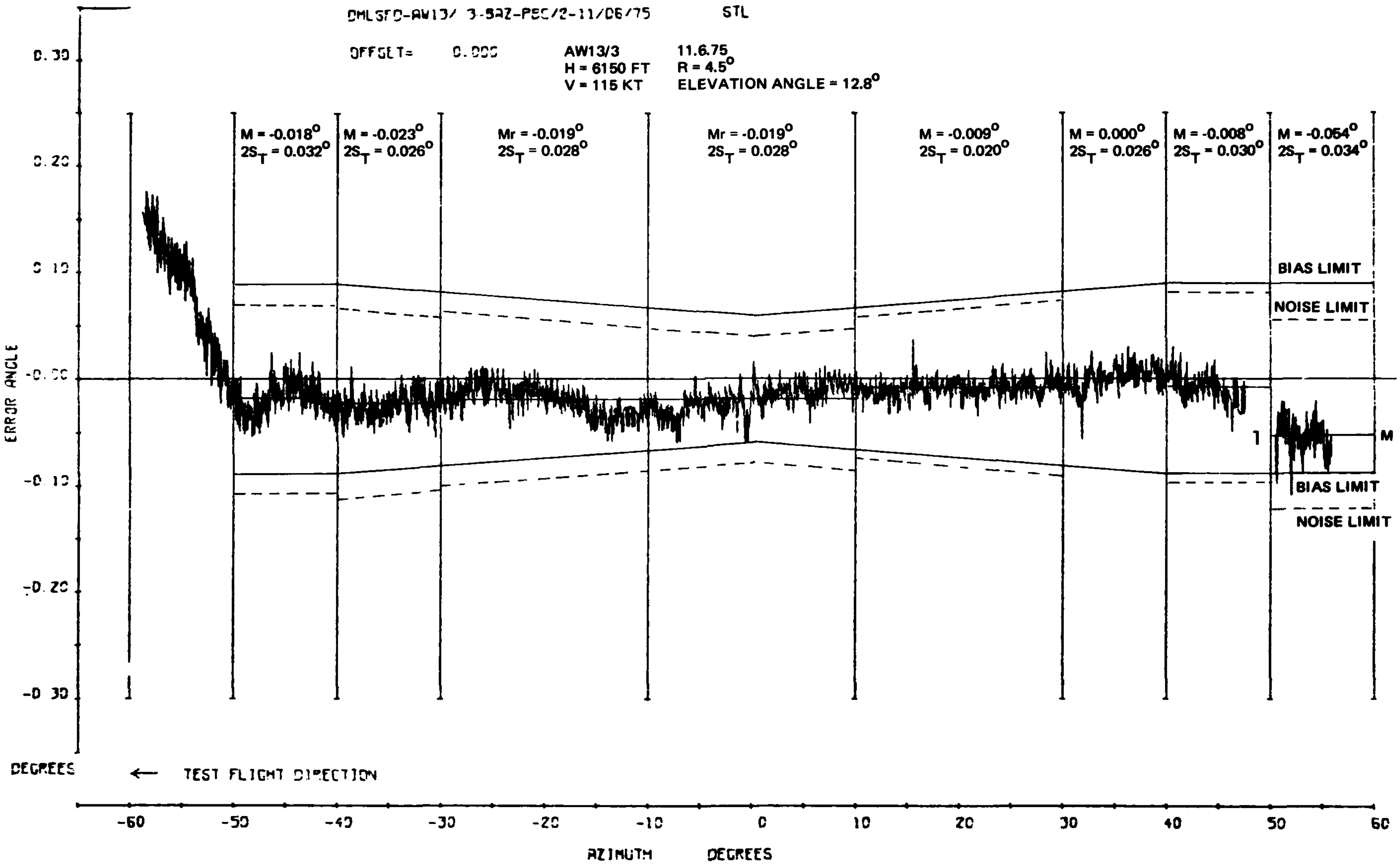


Fig 4.39c Missed approach azimuth orbital flight at 6150 ft and 4.5 n mile radius

Fig 4.39c

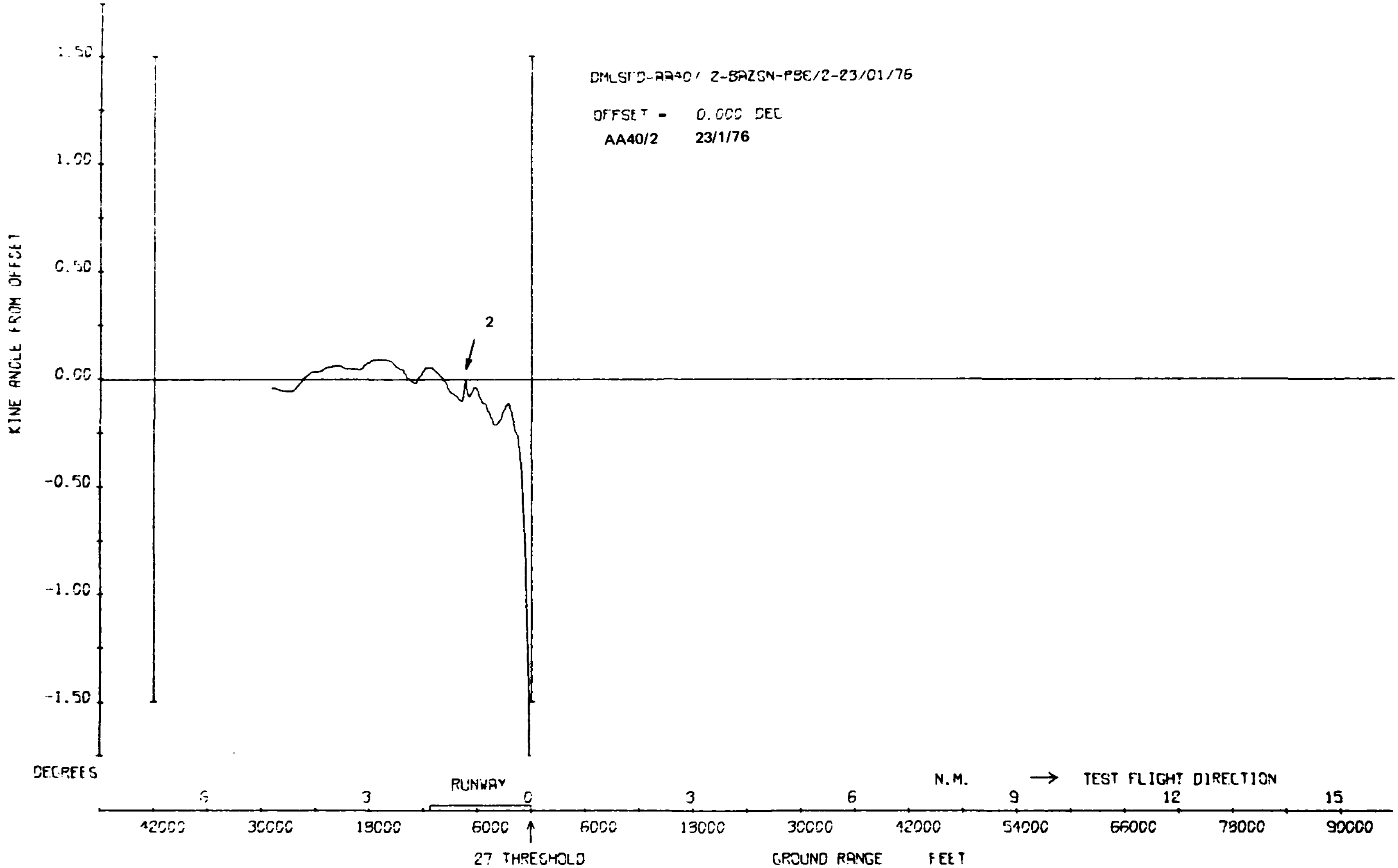


Fig 4.40a 3 degree approach using 60λ array missed approach guidance to low overshoot

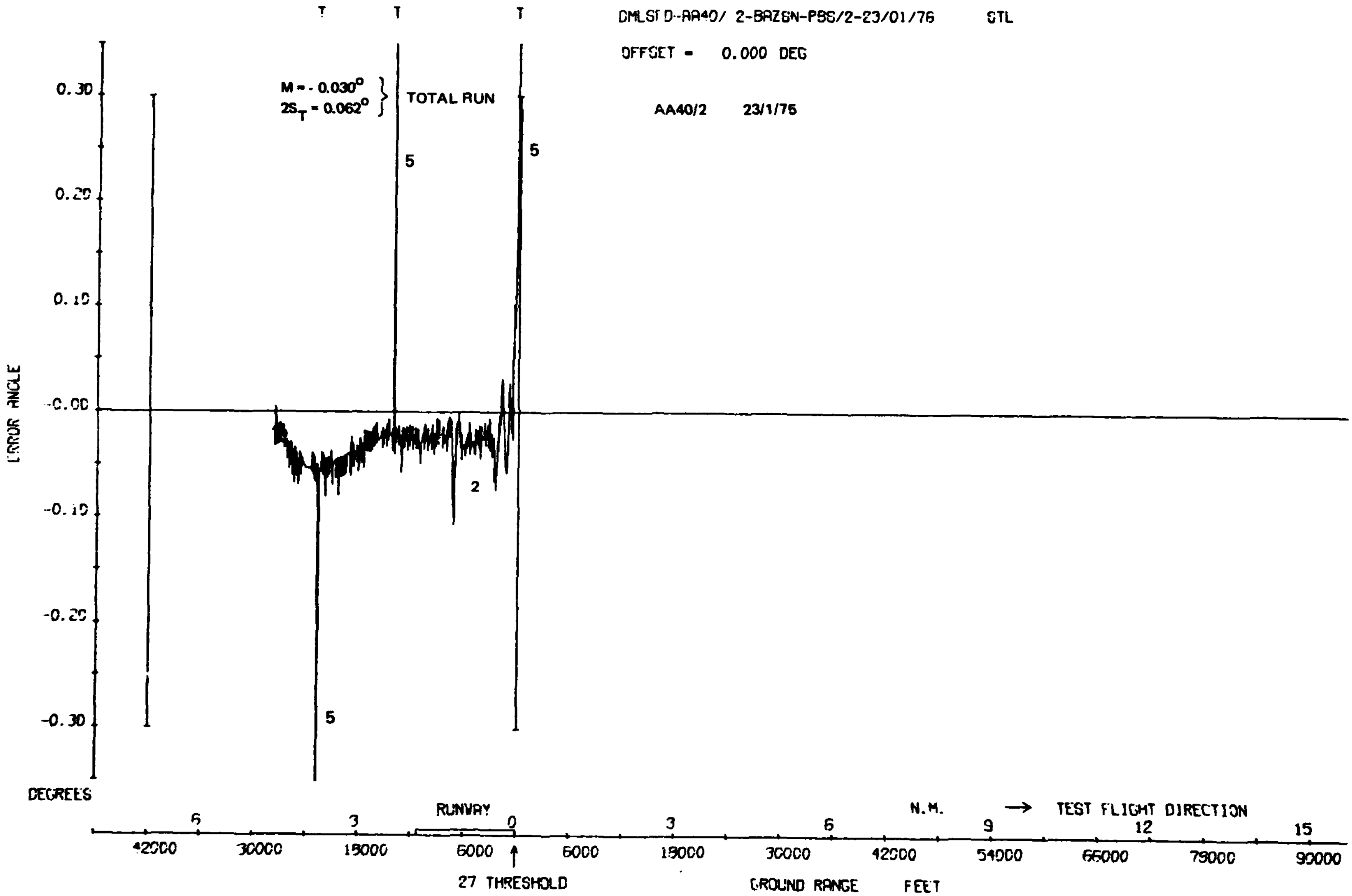


Fig 4.40c 3 degree approach using 60λ array missed approach guidance to low overshoot

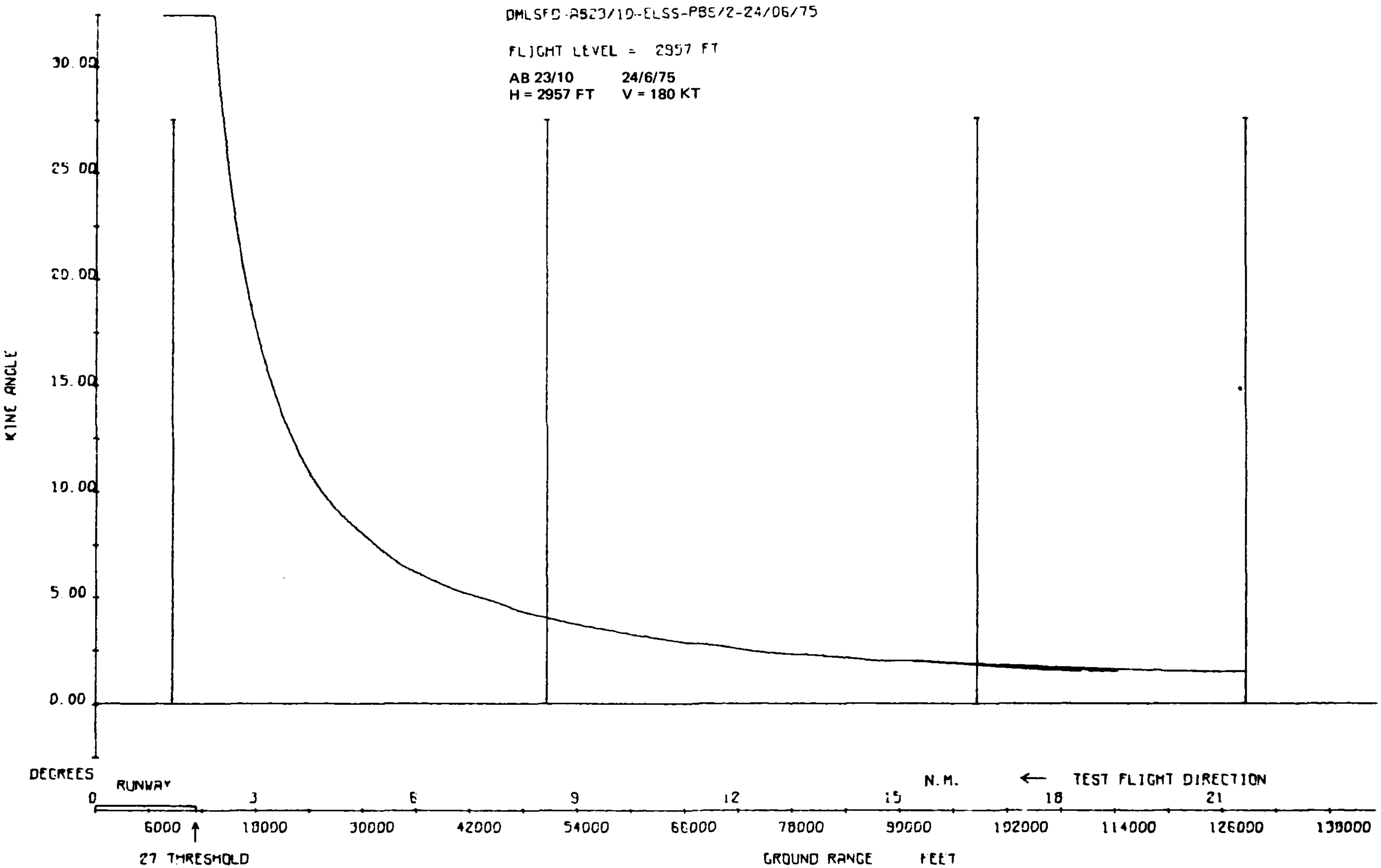


**Fig 4.41a Elevation accuracy. Radial flight at 2957 ft and 0 degree**

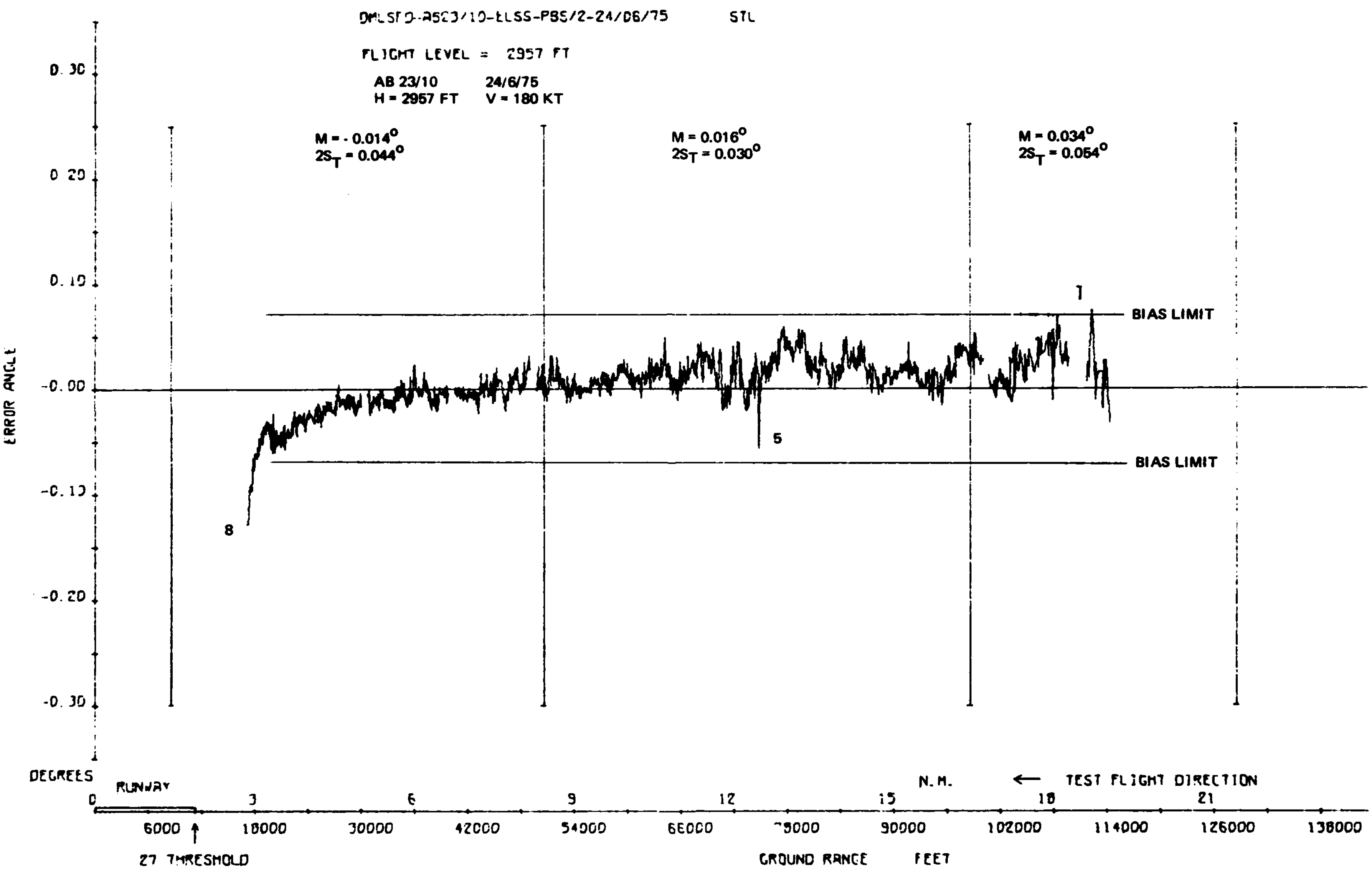


Fig 4.41c Elevation accuracy. Radial flight at 2957 ft and 0 degree

Fig 4.41c

Fig 4.42a

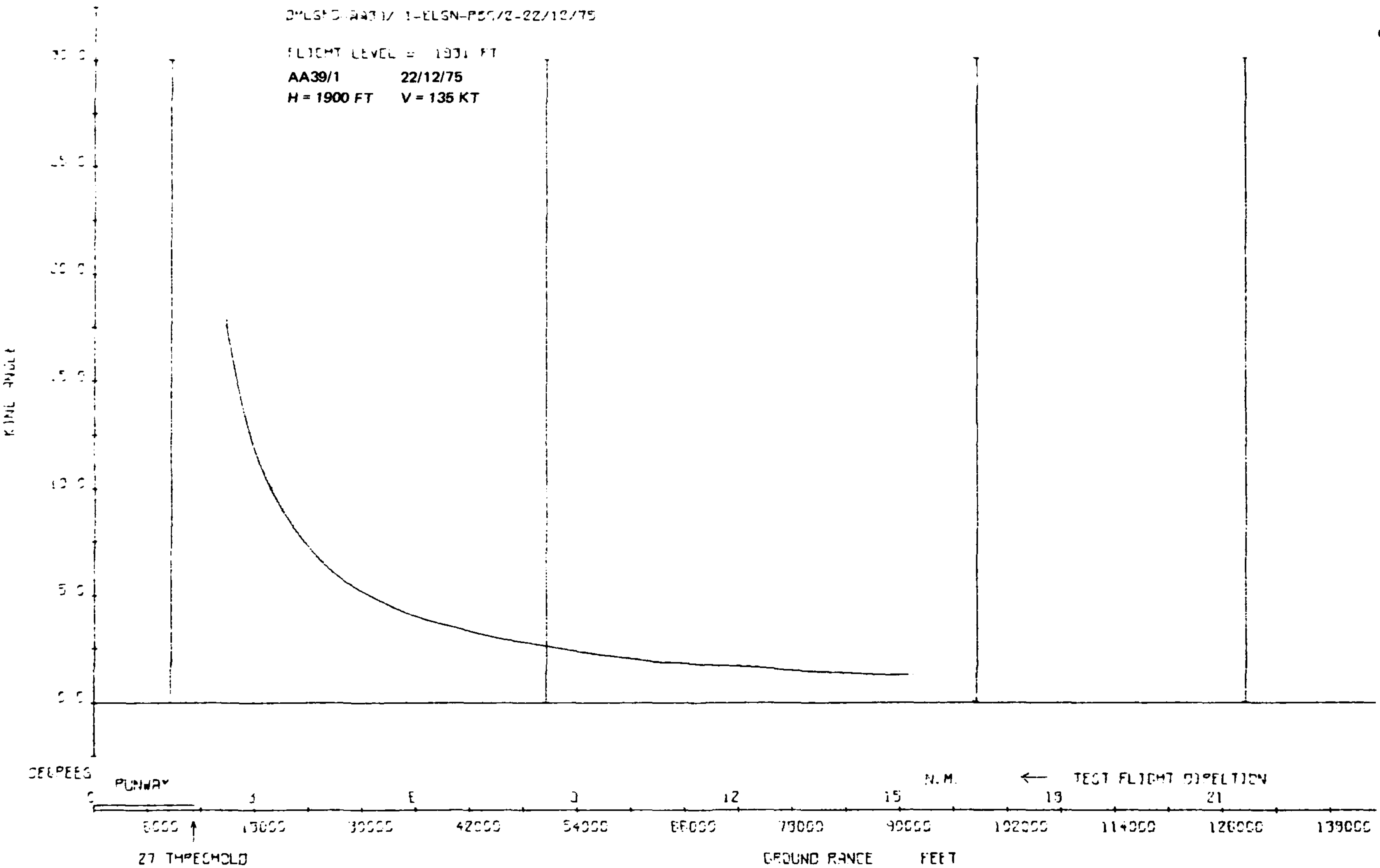


Fig 4.42a Elevation accuracy radial flight at 1900 ft and on —44 degrees radial

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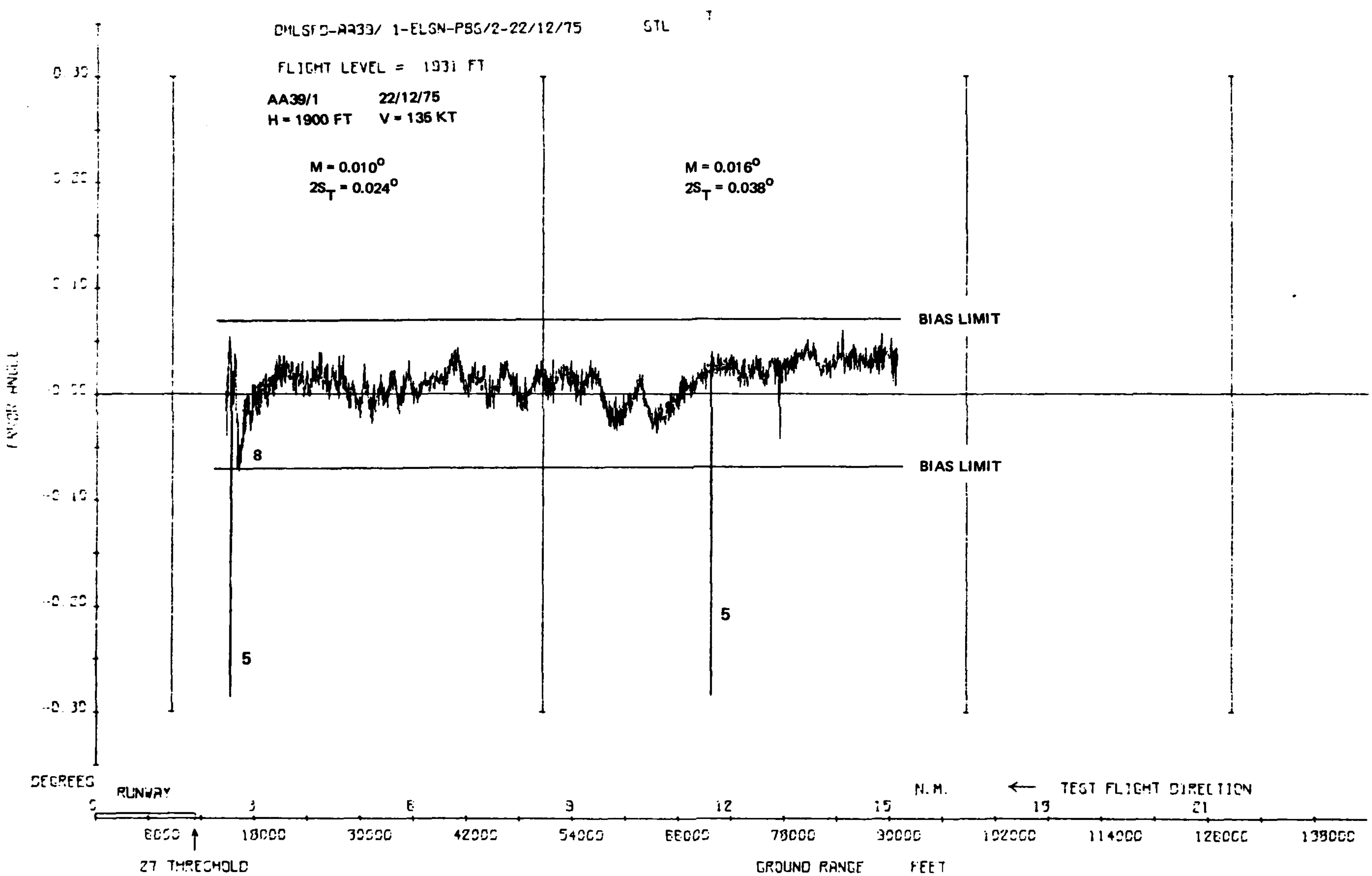


Fig 4.42c Elevation accuracy radial flight at 1900 ft and on –44 degrees radial

Fig 4.43a

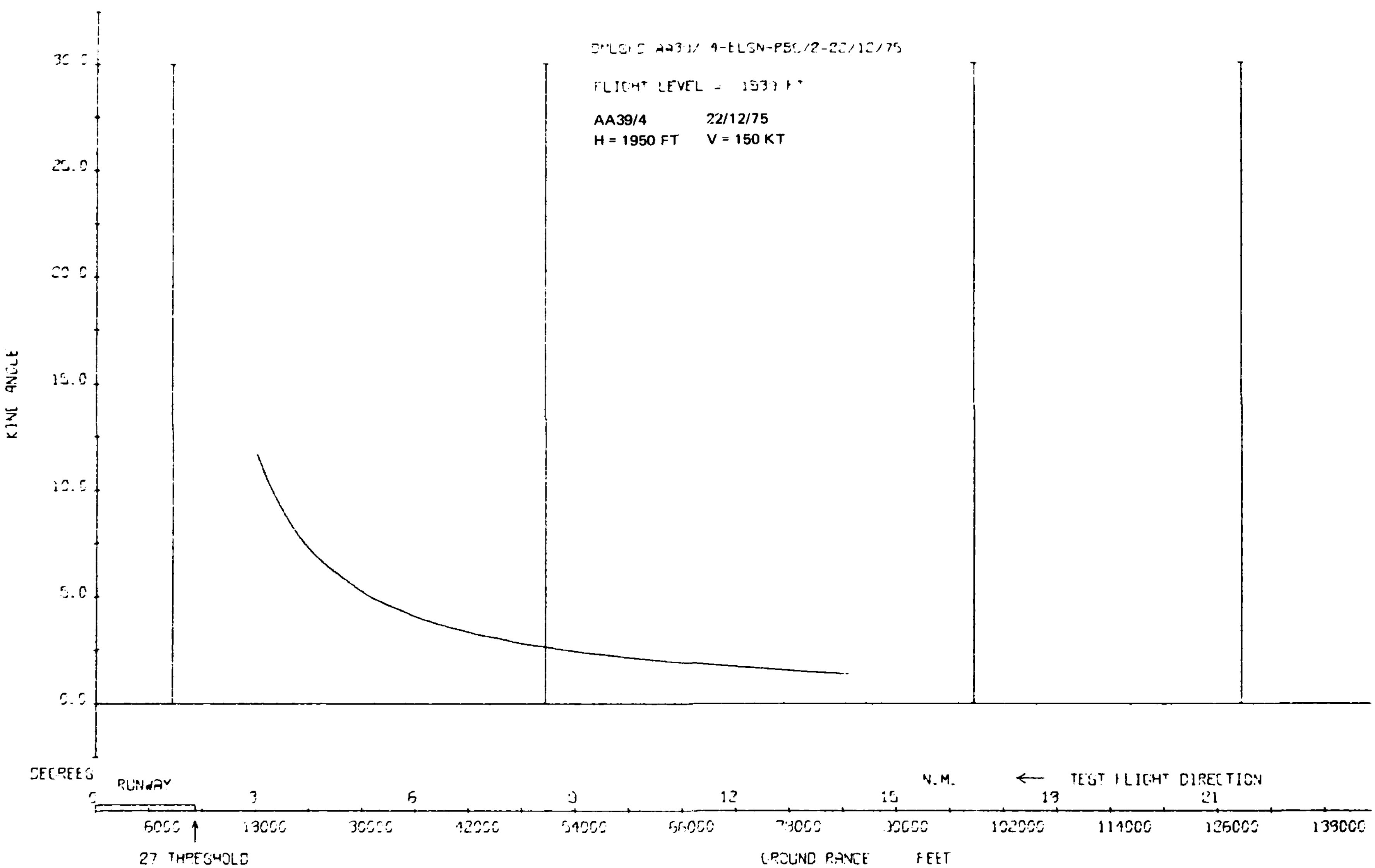


Fig 4.43a Elevation accuracy radial flight at 1950 ft and on +51 degrees radial

TR 79052

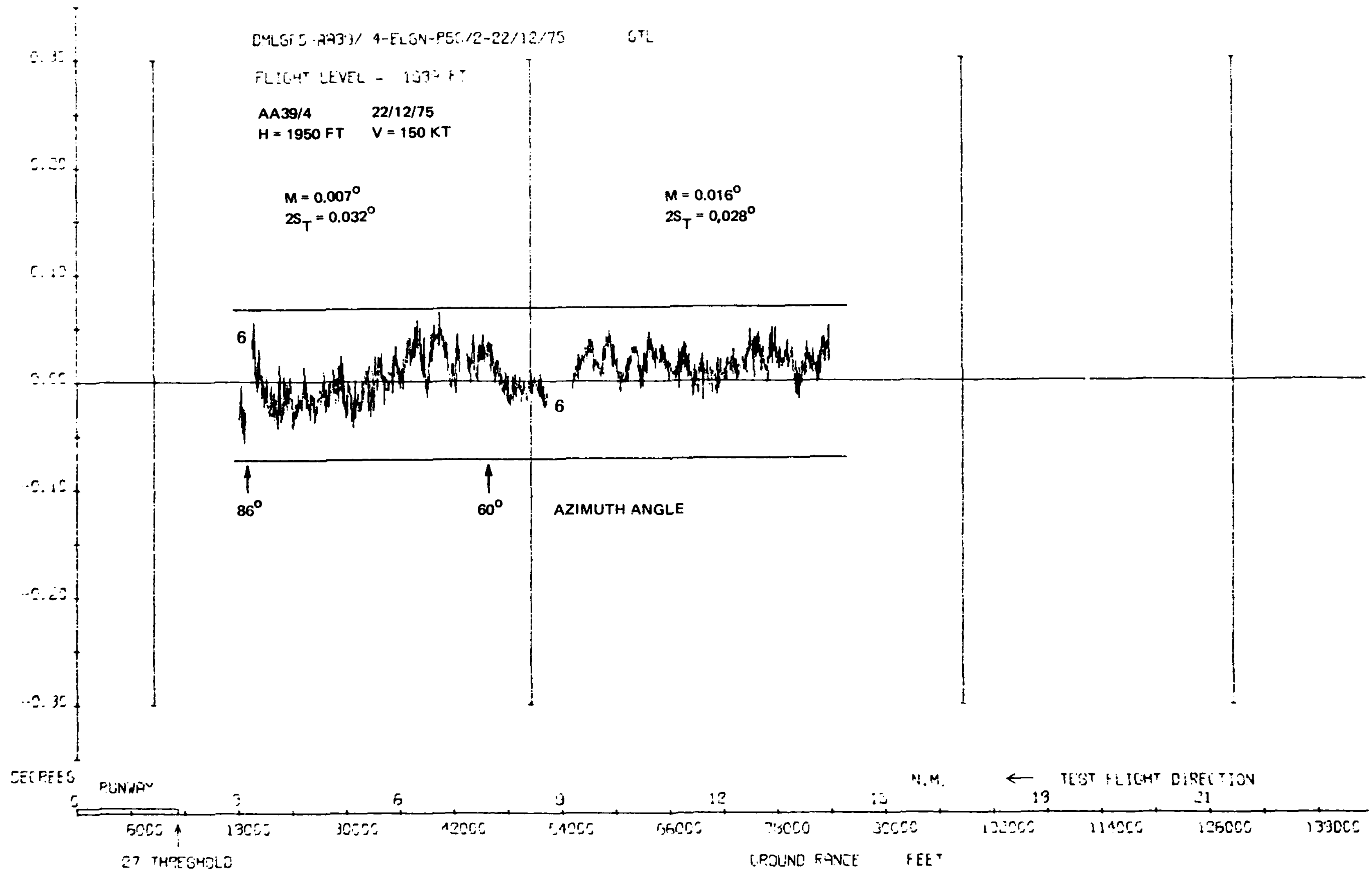


Fig 4.43c Elevation accuracy radial flight at 1950 ft and on +51 degrees radial

Fig 4.44a

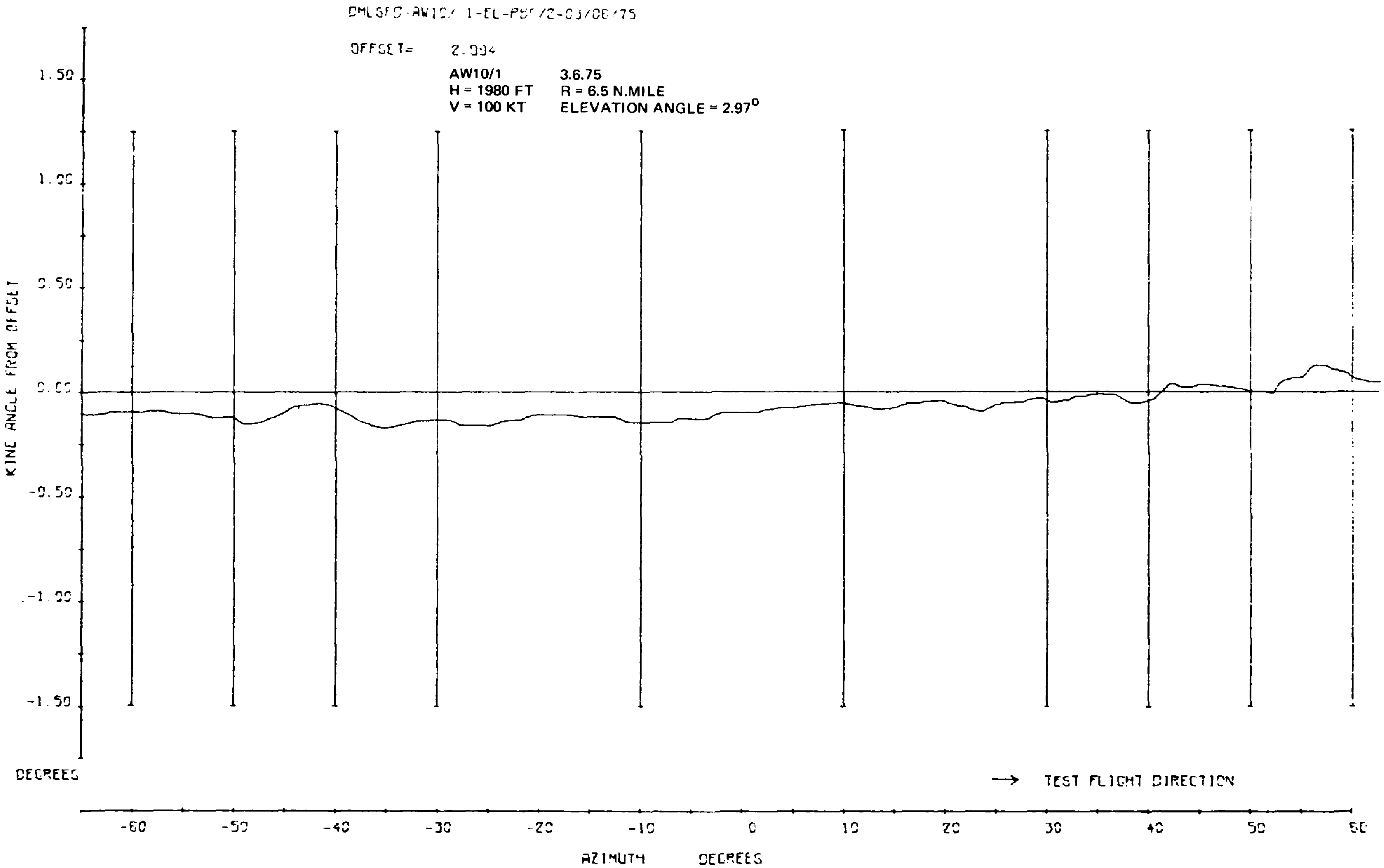


Fig 4.44a Elevation orbital flight at 1980 ft and 6.5 n mile radius

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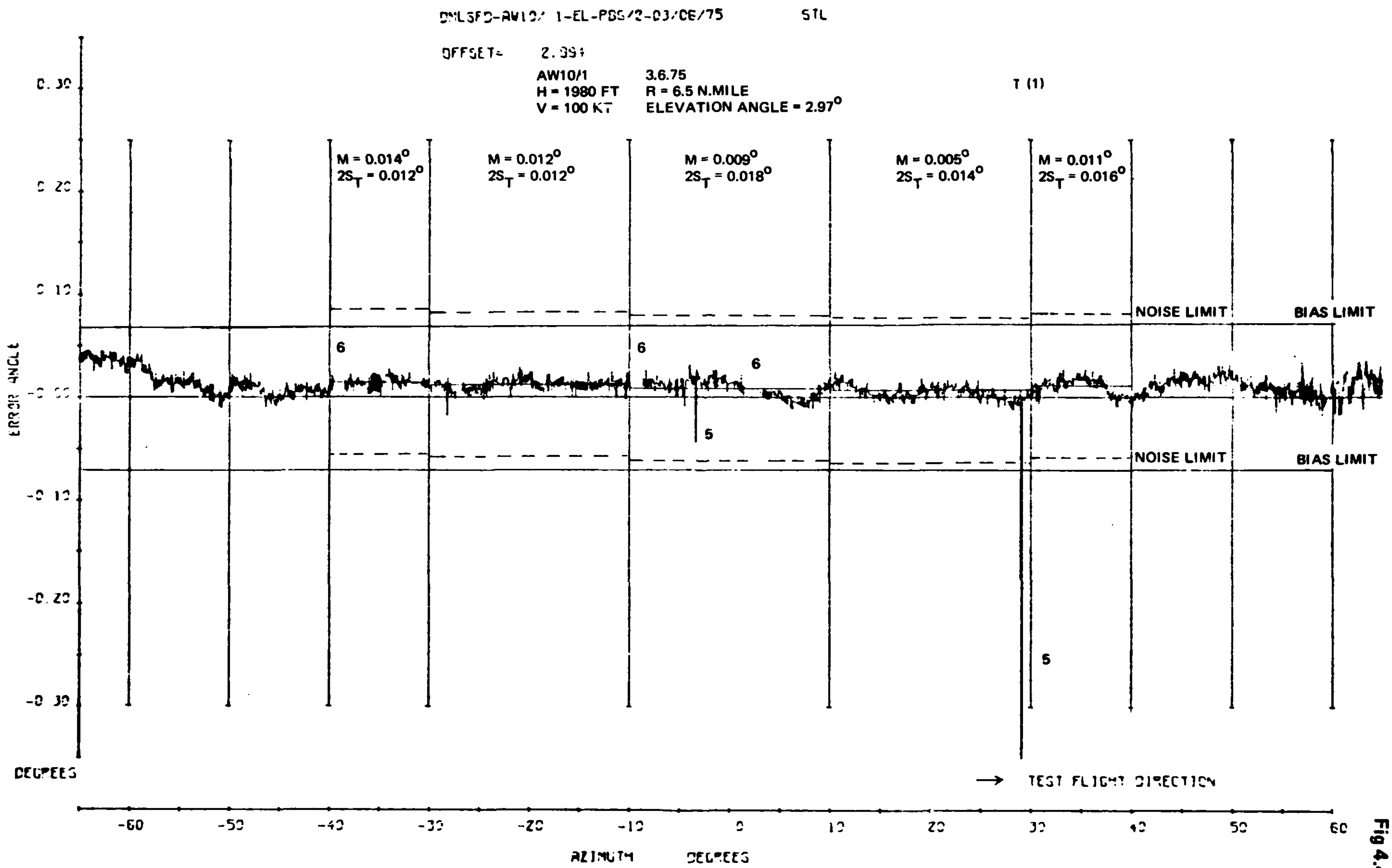


Fig 4.44c Elevation orbital flight at 1980 ft and 6.5 n mile radius

Fig 4.45a

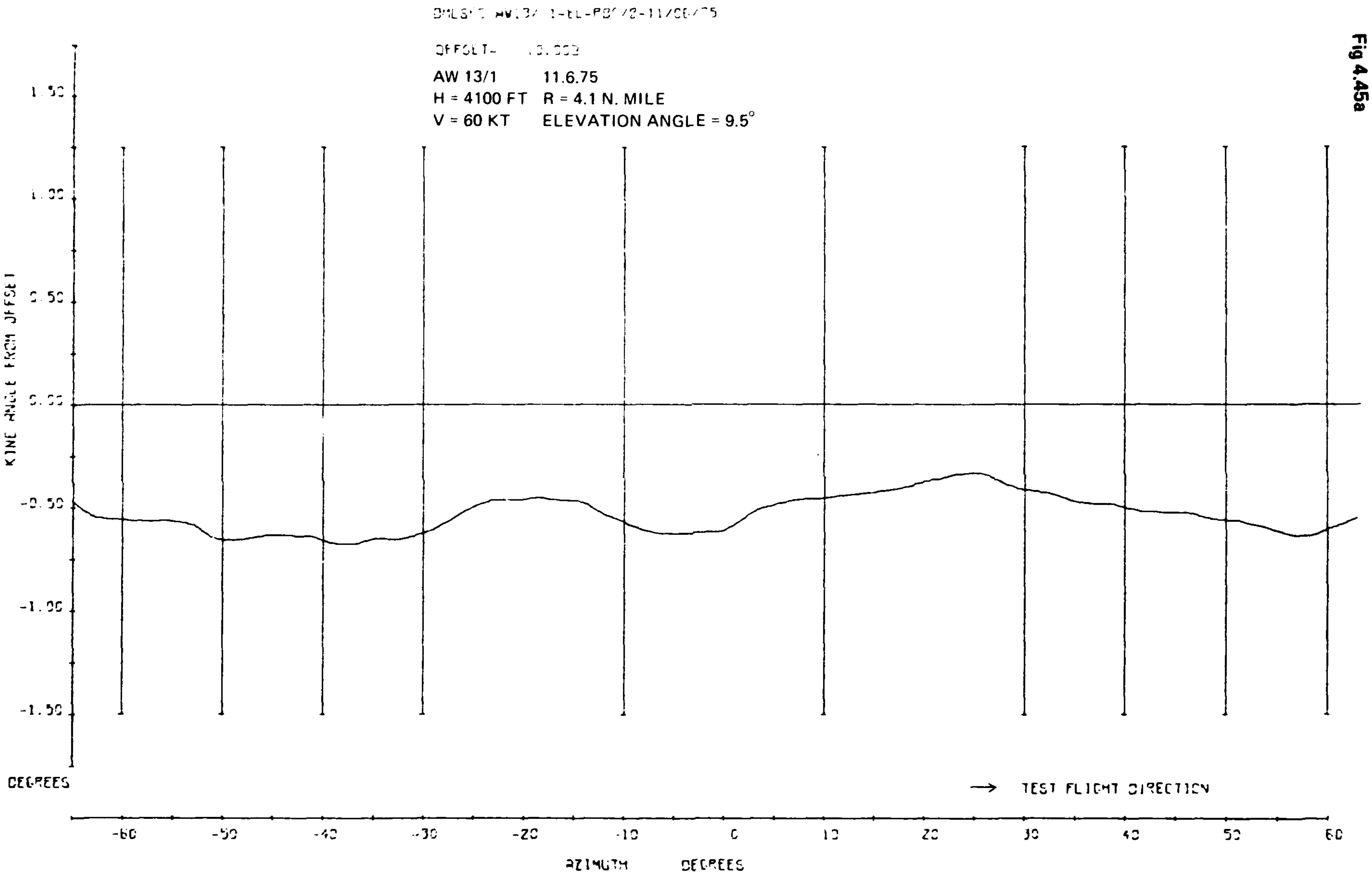


Fig 4.45a Elevation orbital flight at 4100 ft and 4.1 n mile radius

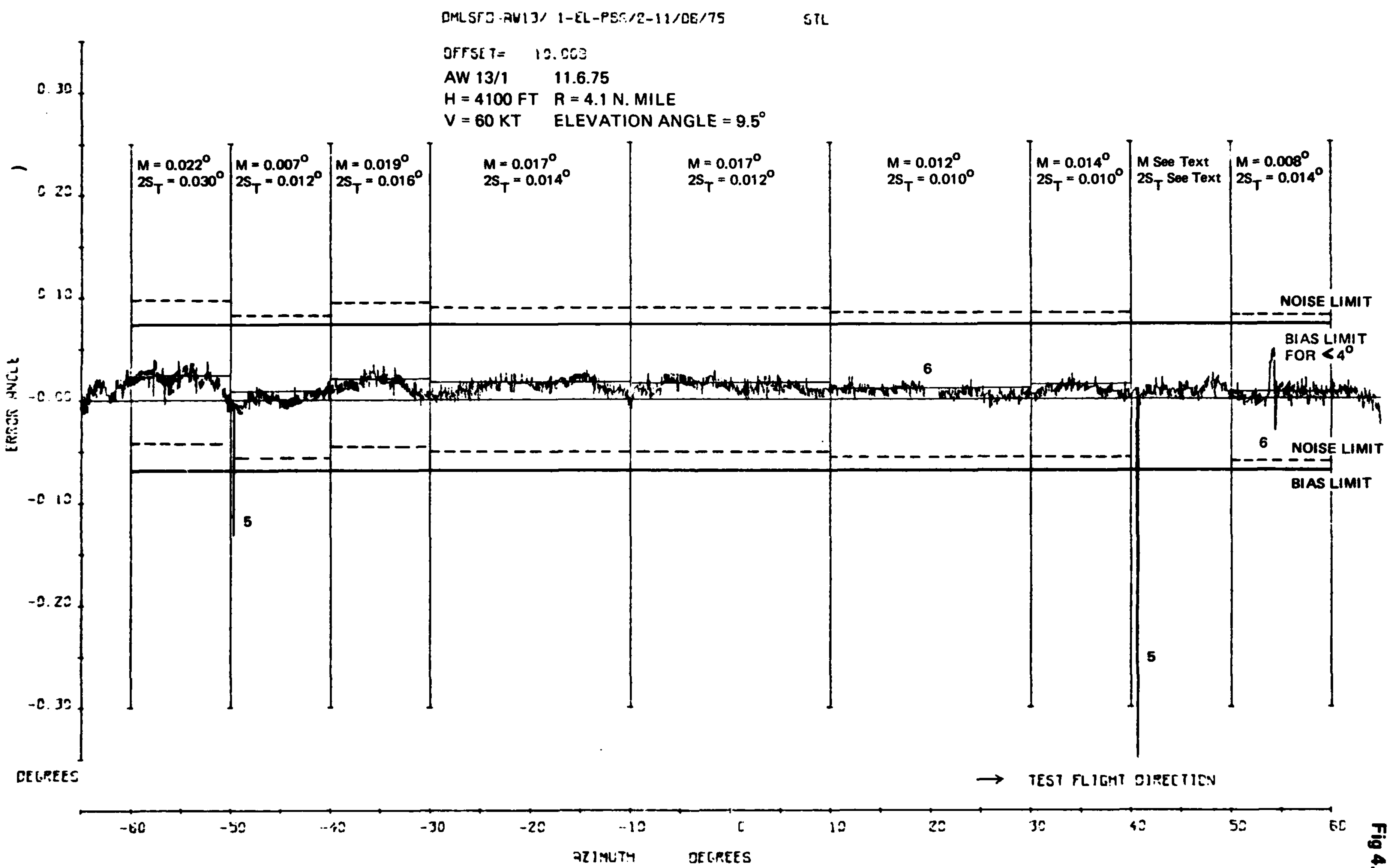


Fig 4.45c Elevation orbital flight at 4100 ft and 4.1 mile radius

Fig 4.45c

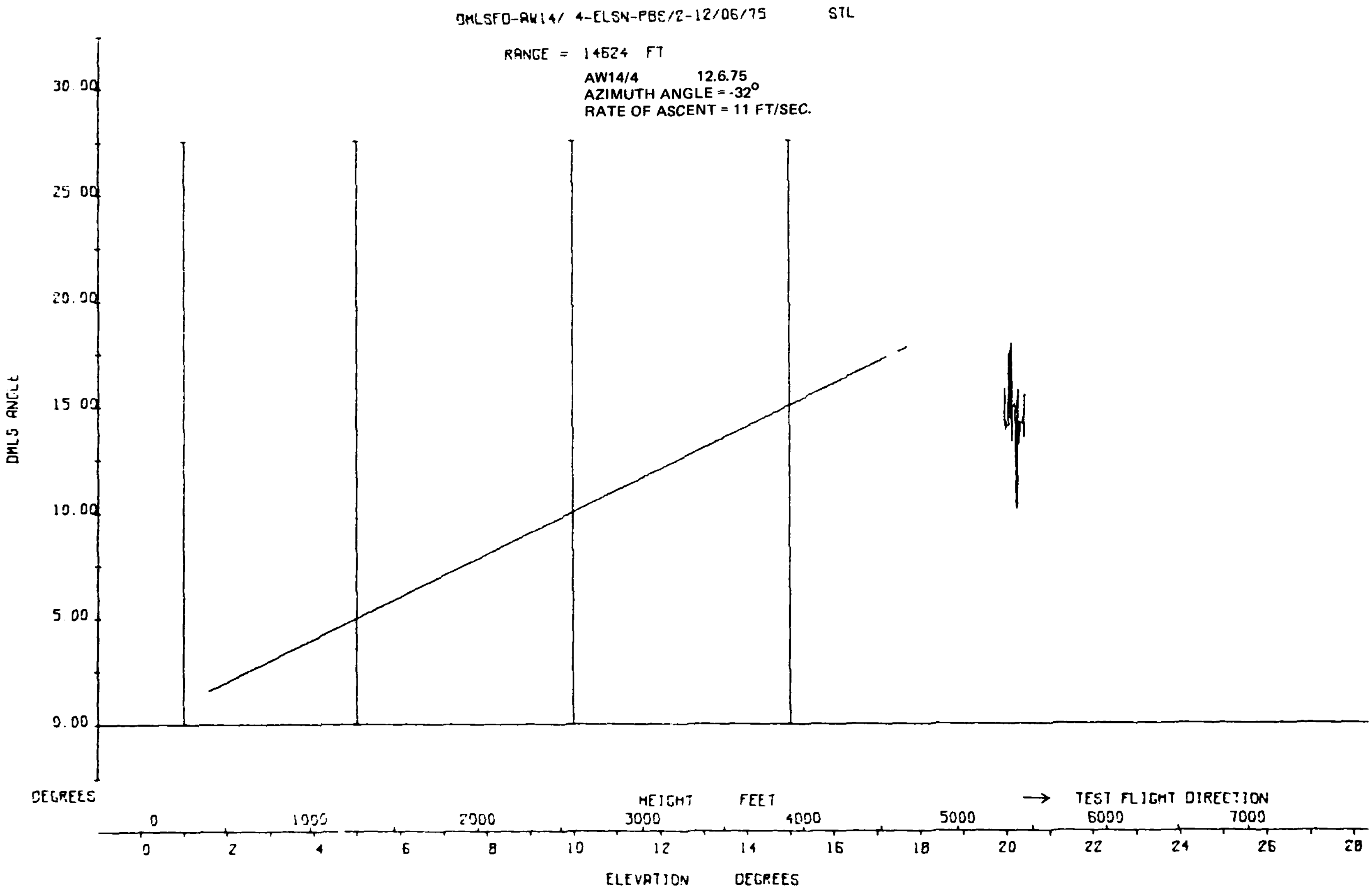


Fig 4.46a/b Elevation vertical ascent

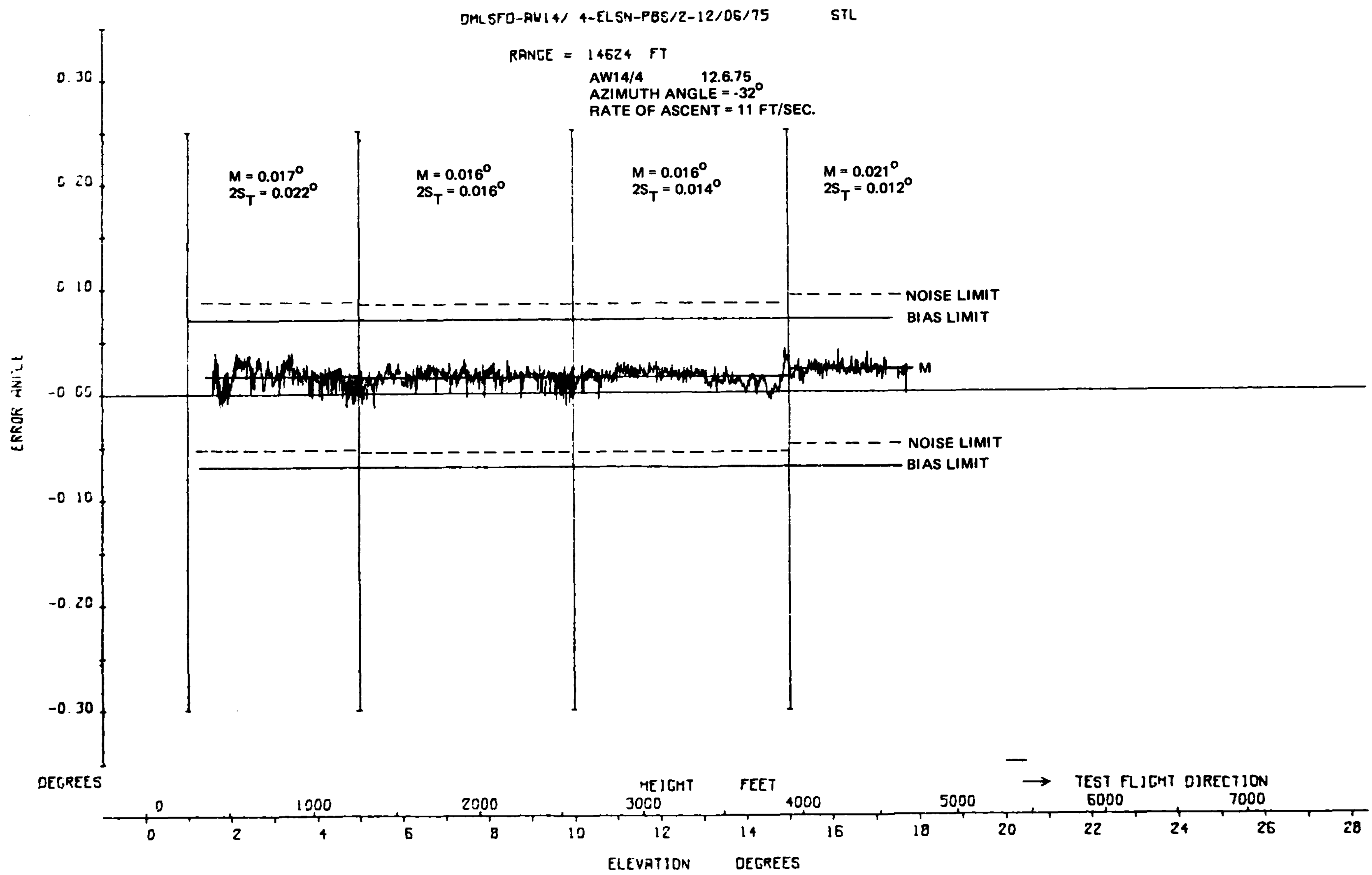


Fig 4.46c Elevation vertical ascent

Fig 4.47a

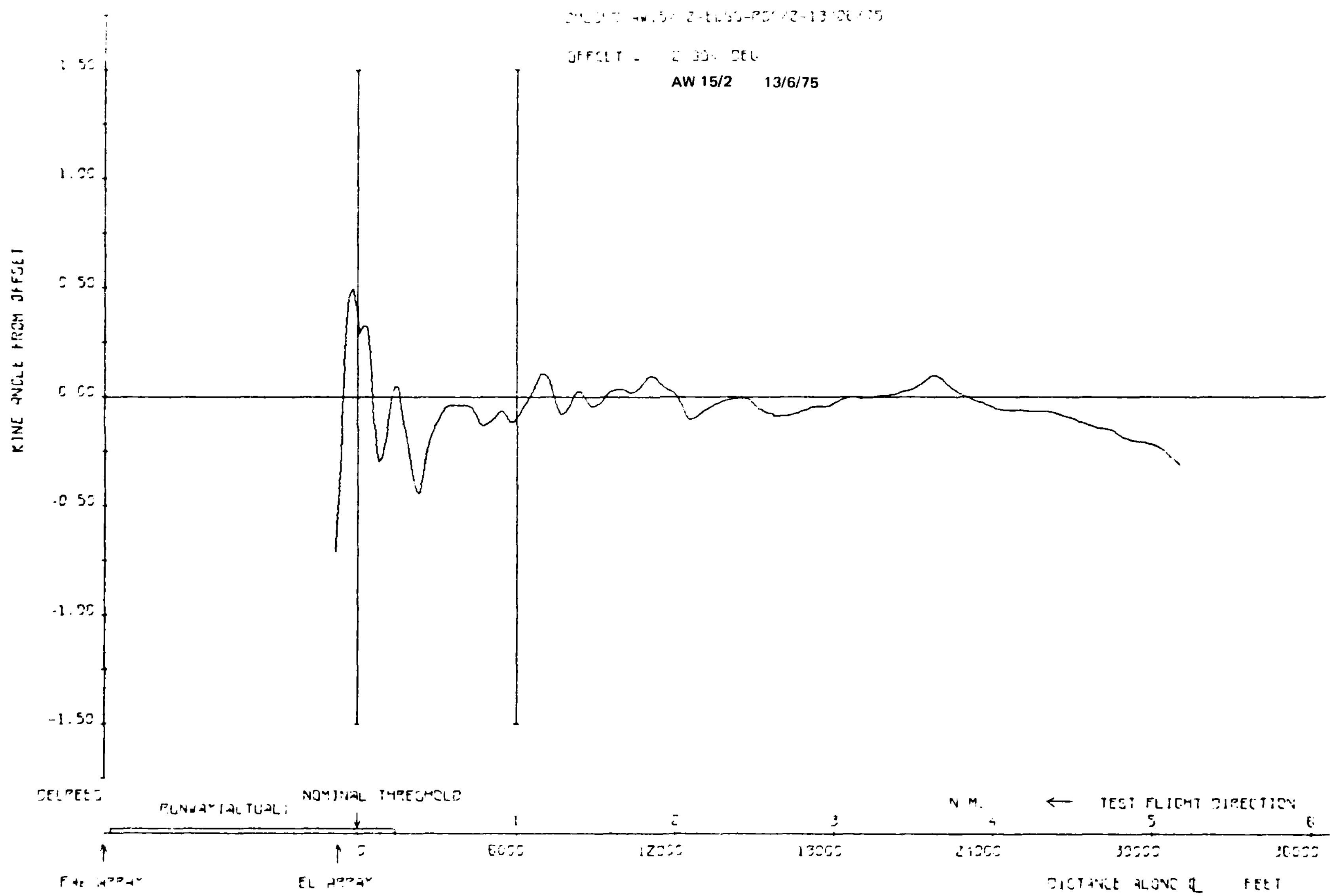


Fig 4.47a Elevation accuracy. 3 degree approach to touchdown

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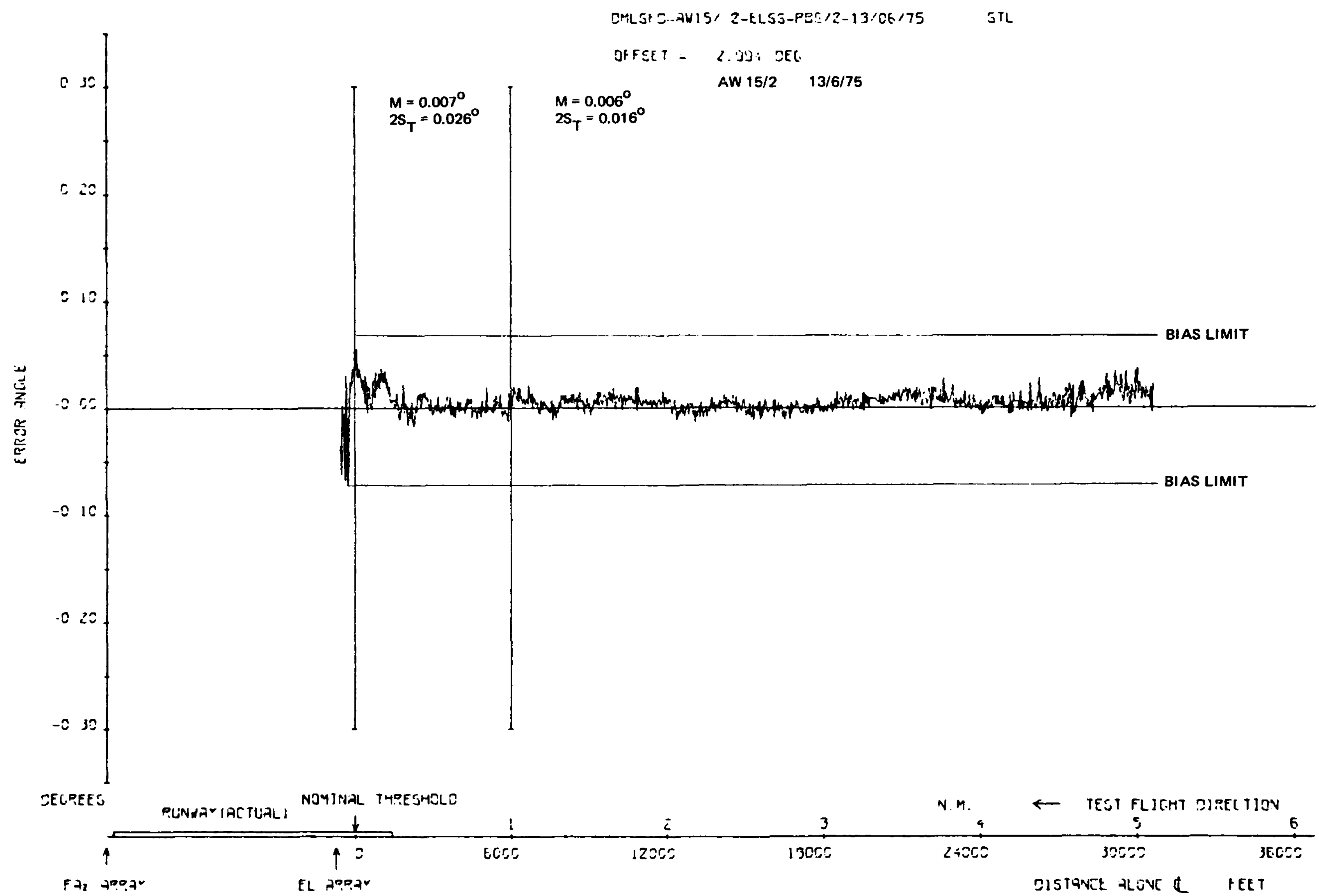


Fig 4.47c Elevation accuracy. 3 degree approach to touchdown

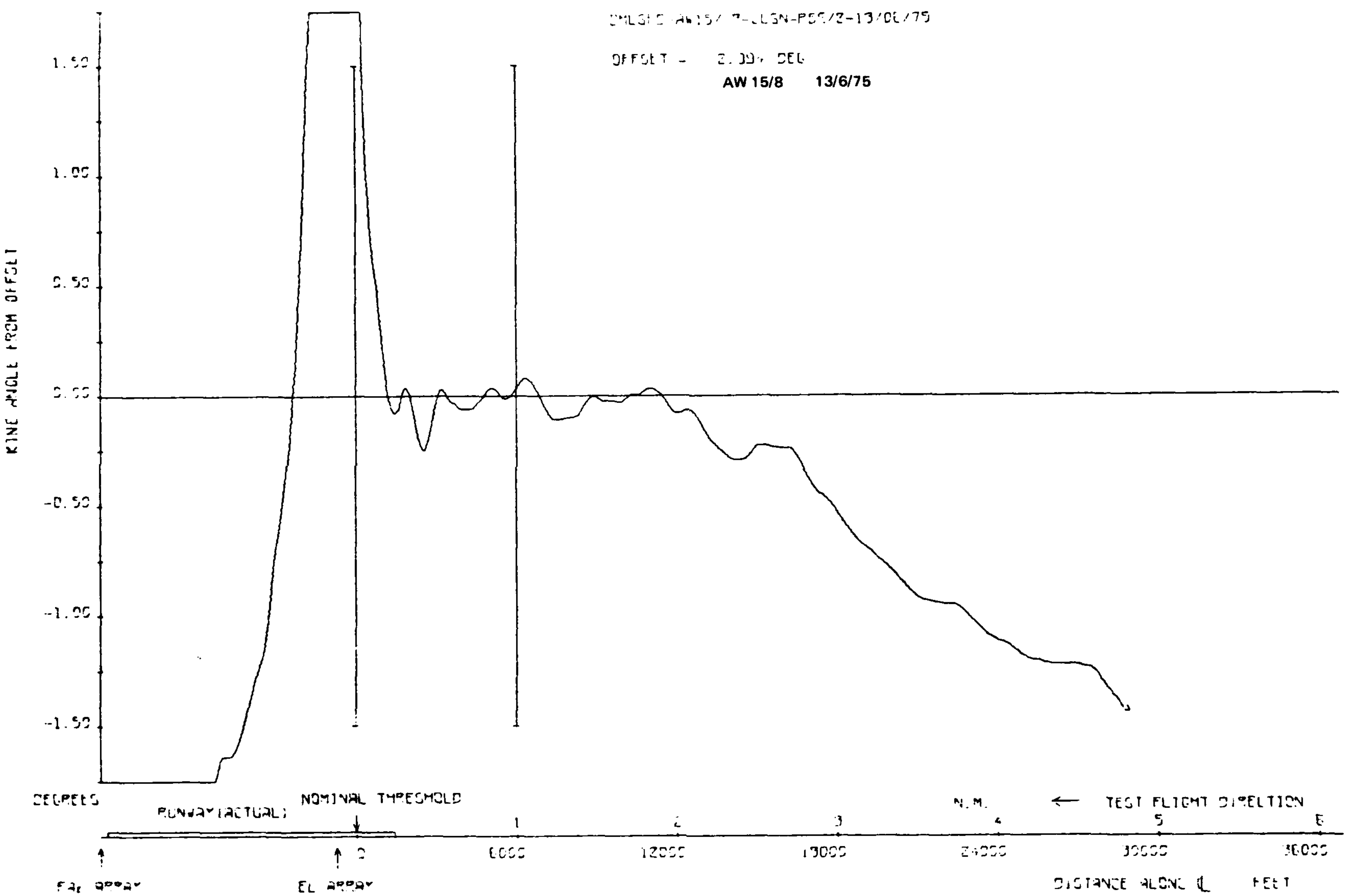


Fig.4.48a Elevation accuracy. 3 degree approach to 100 ft level overfly

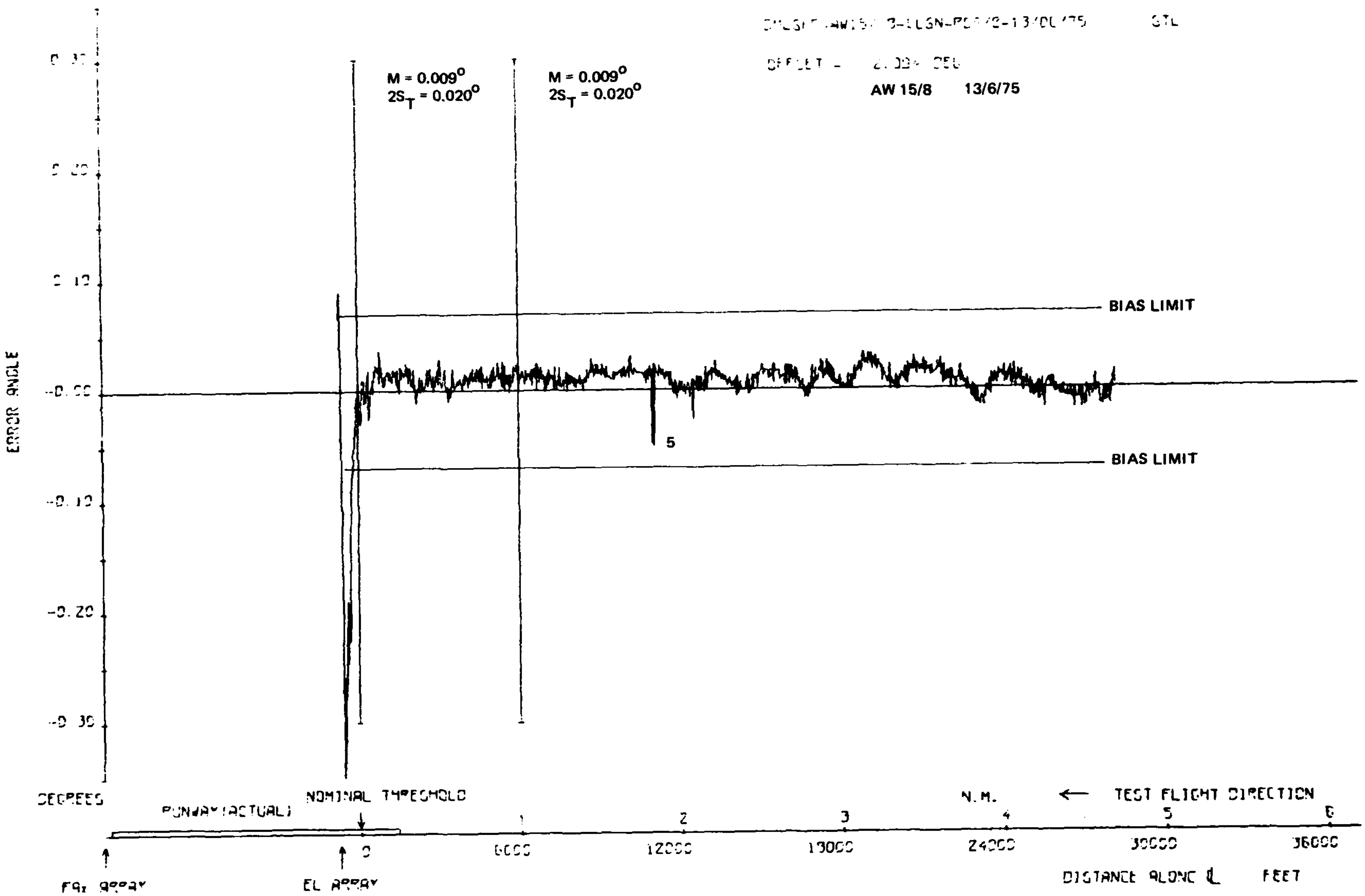


Fig 4.48c Elevation accuracy. 3 degree approach to 100 ft level overfly

Fig 4.48c

Fig 4.49a

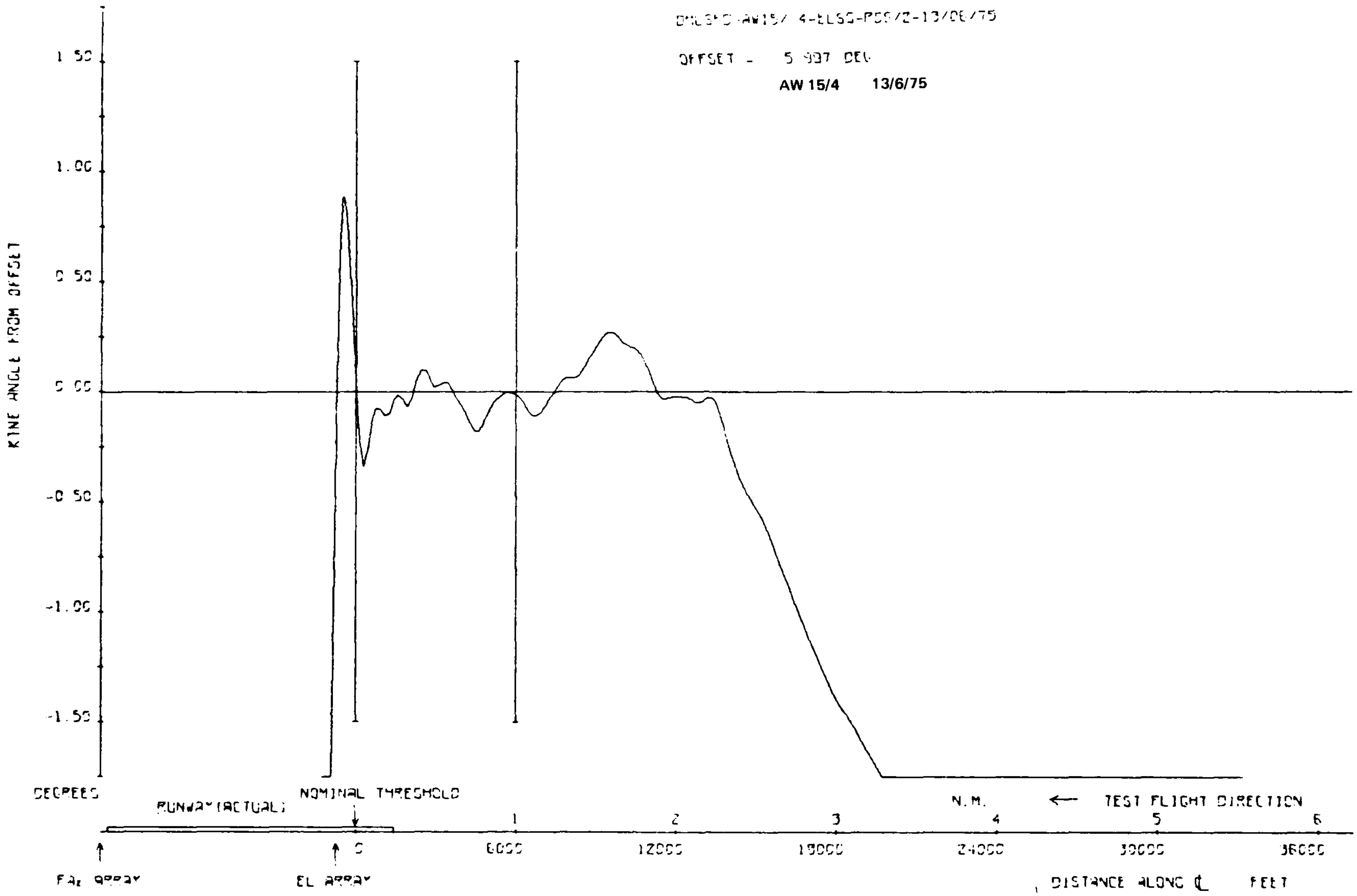


Fig 4.49a Elevation accuracy. 6 degree approach to 50 ft

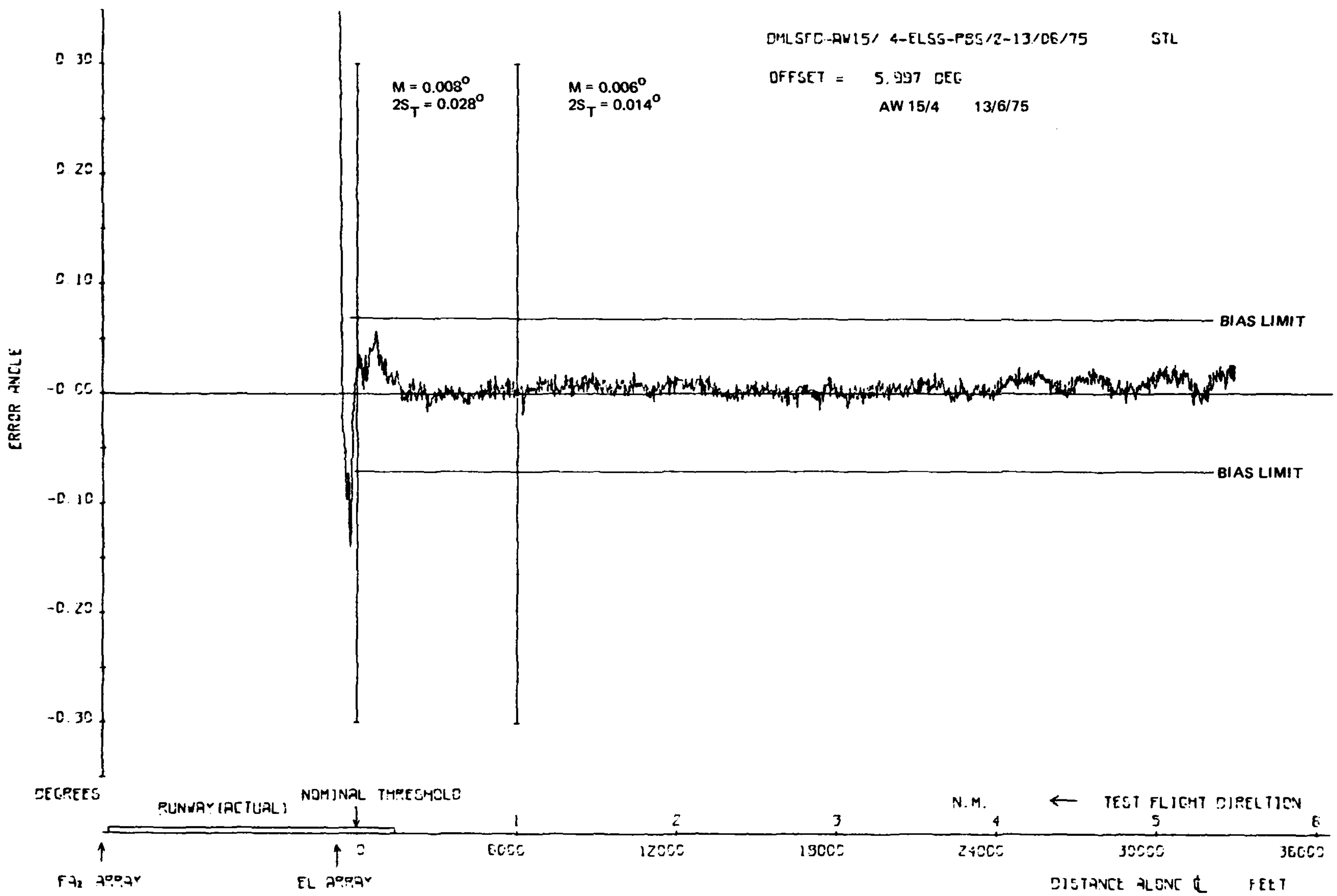


Fig 4.49c Elevation accuracy. 6 degree approach to 50 ft

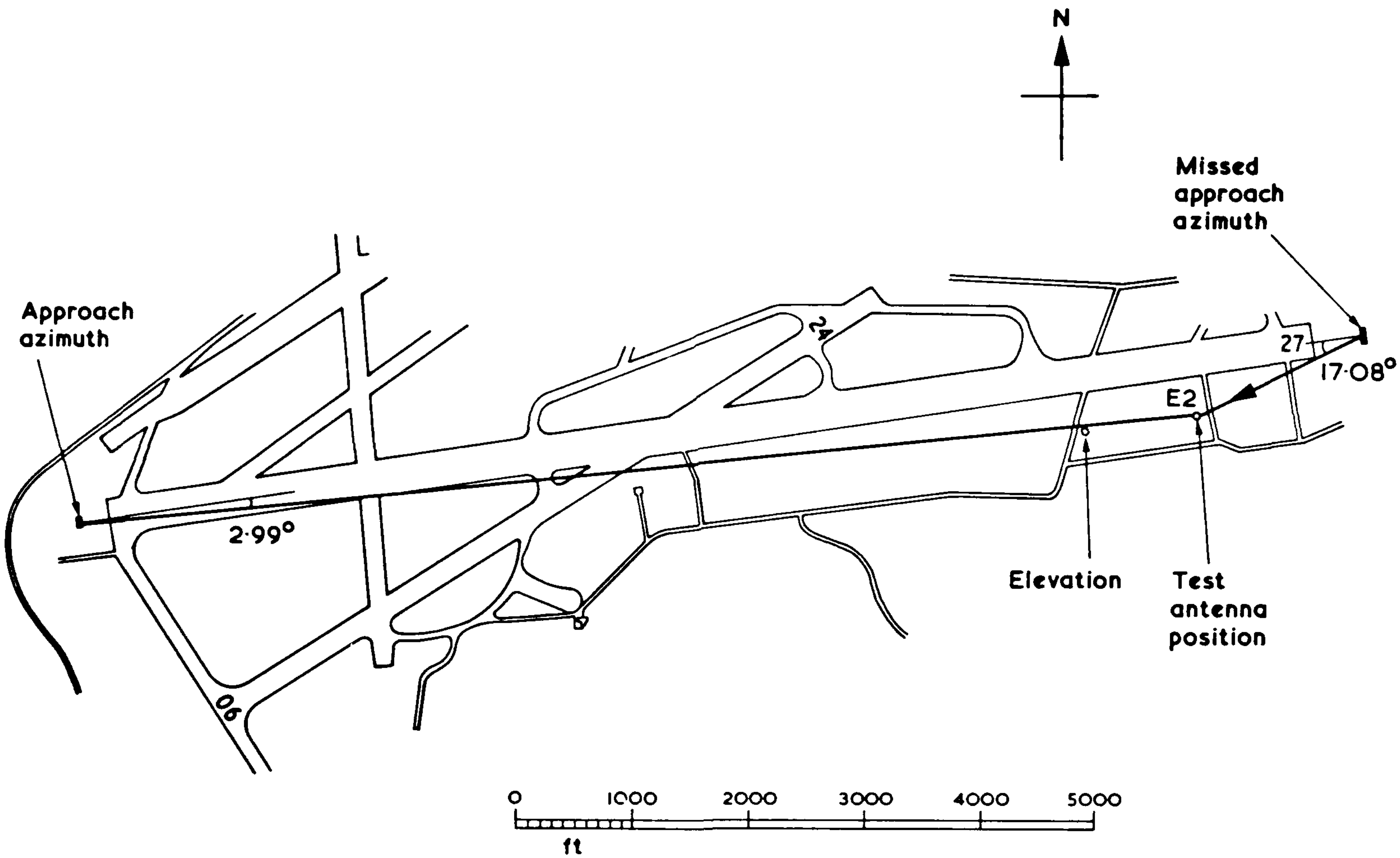


Fig 4.50 Stability test – general site plan Bedford

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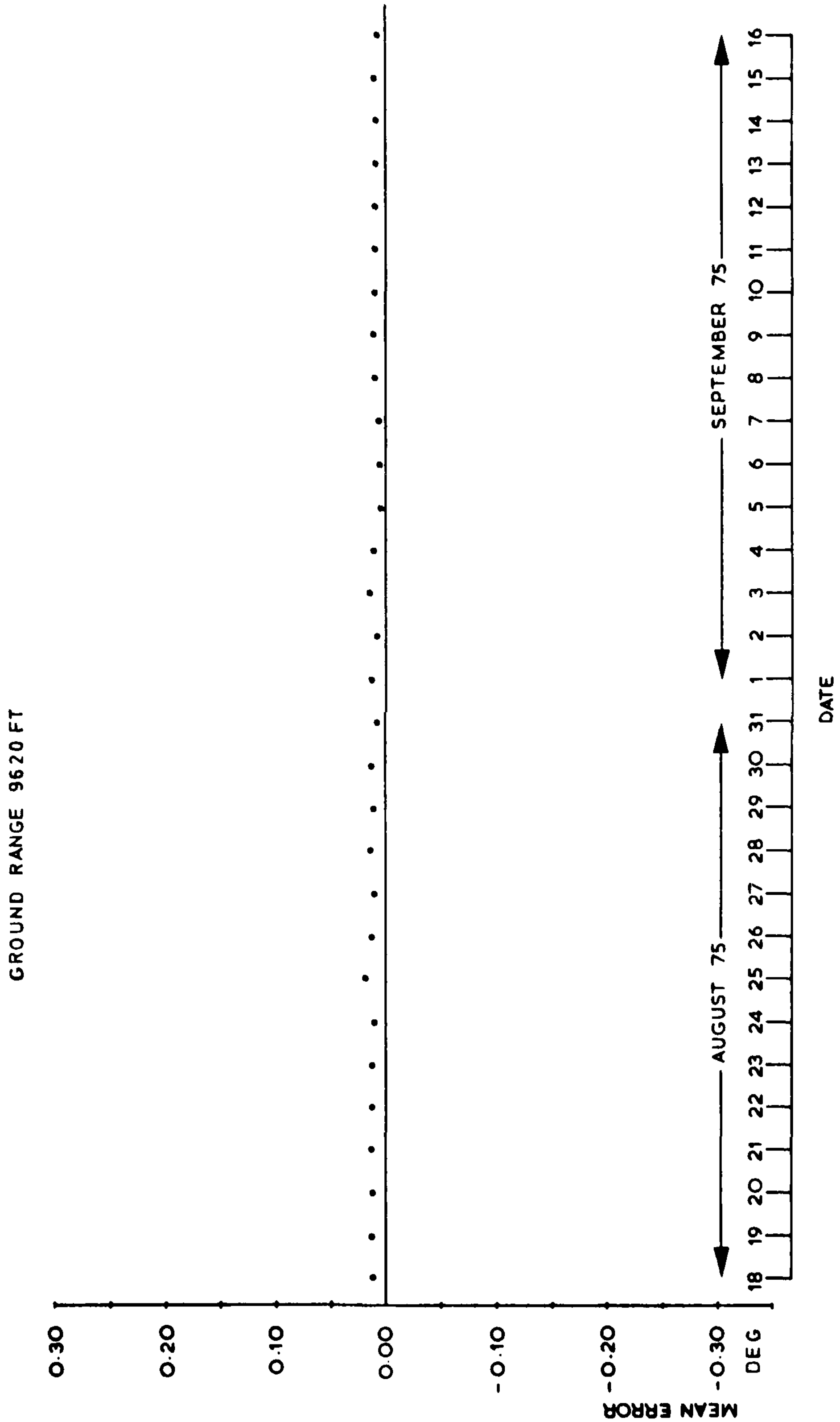


Fig 4.51 Stability test – approach mean error

Fig 4.52

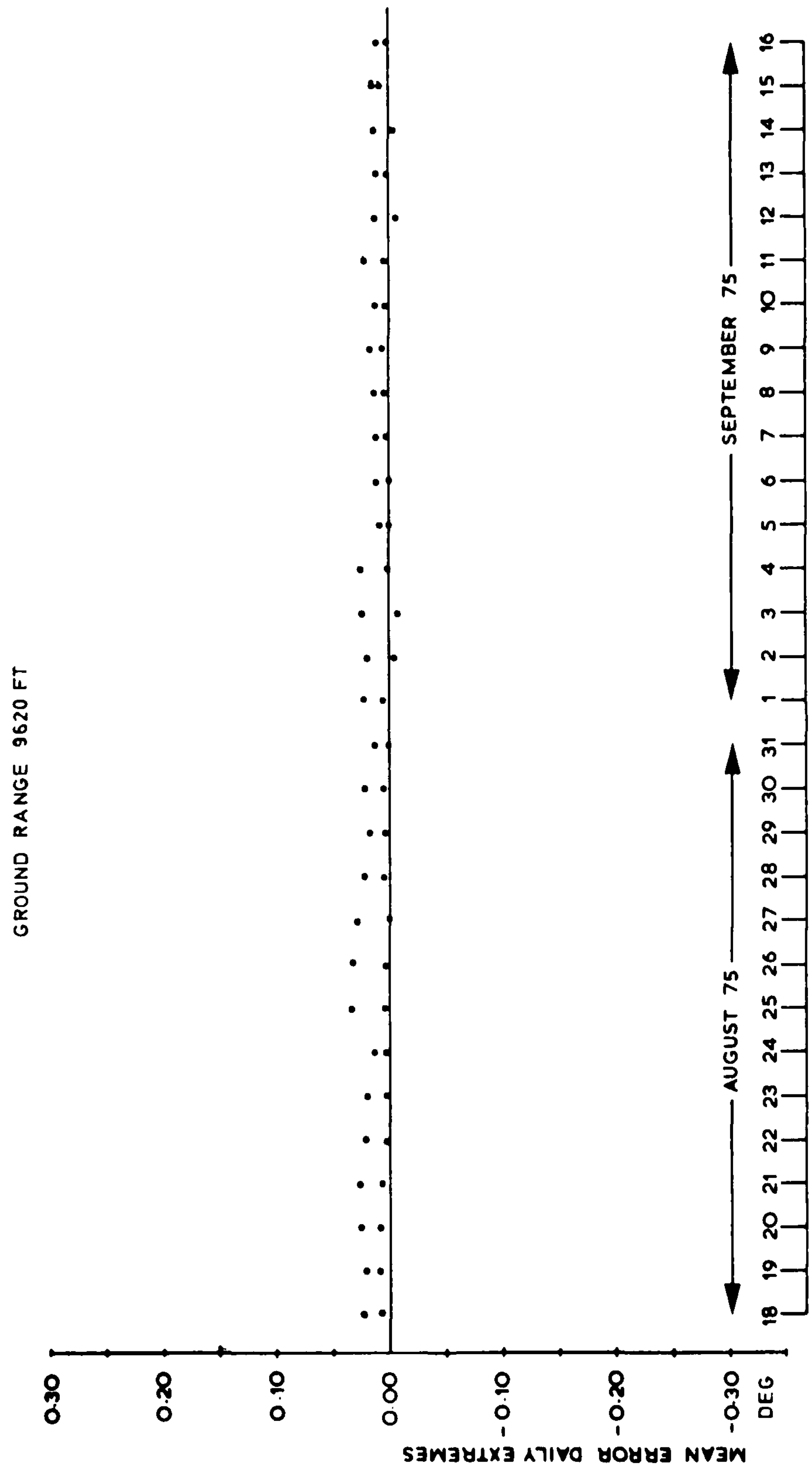


Fig 4.52 Stability test — approach azimuth daily mean error extremes

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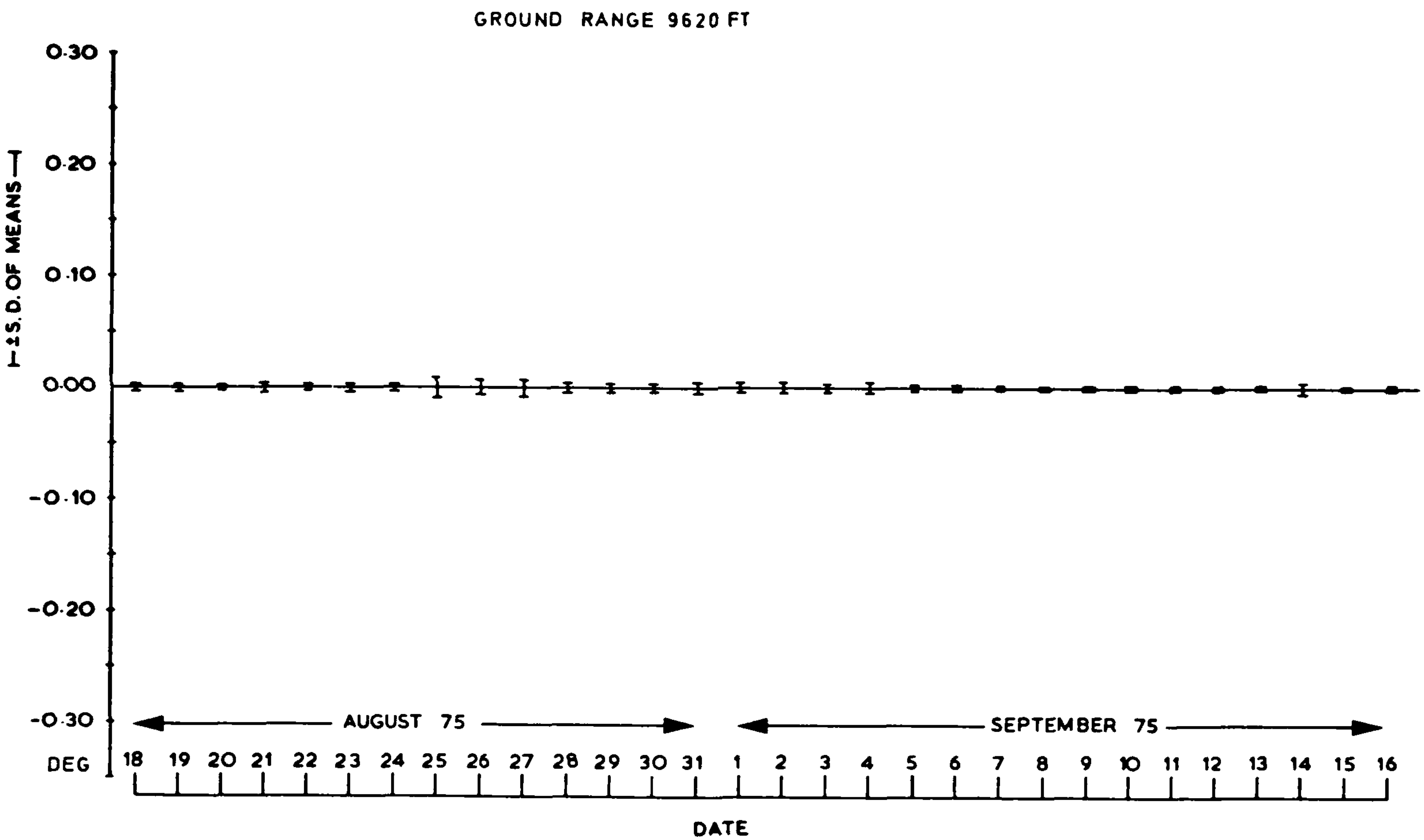


Fig 4.53 Stability test — approach azimuth daily standard deviation of means

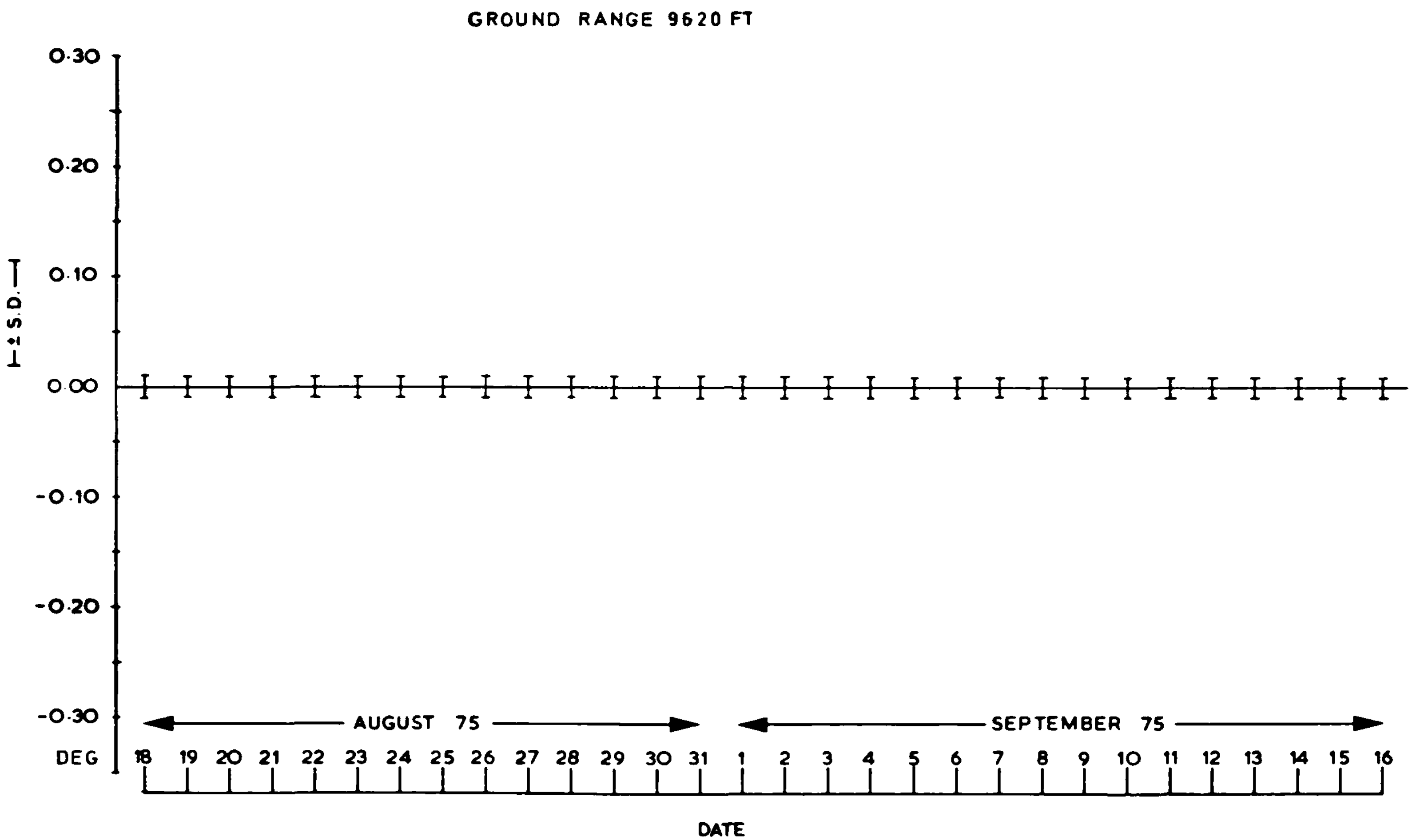


Fig 4.54 Stability test – approach azimuth noise error rms

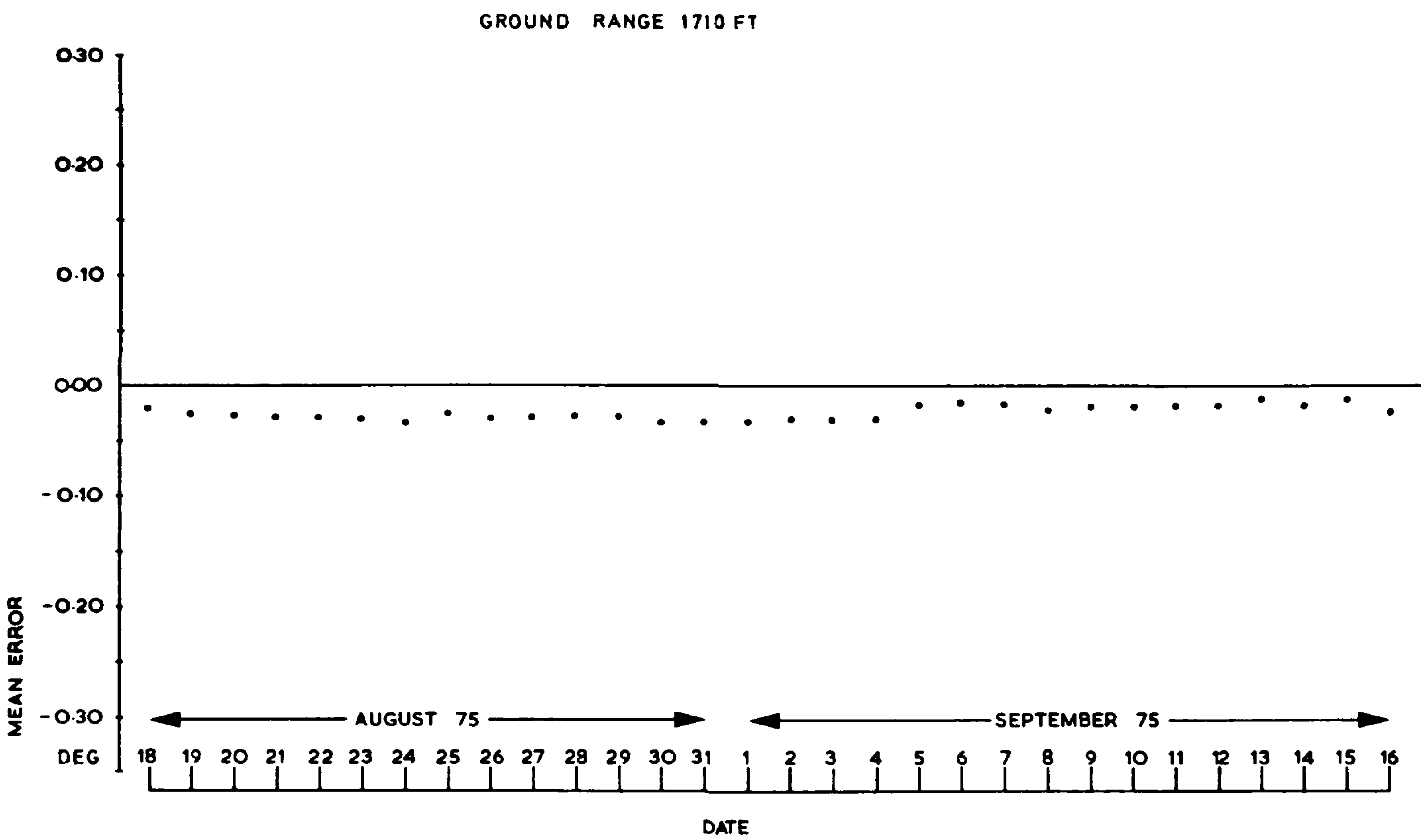


Fig 4.55 Stability test – missed approach azimuth mean error

Fig 4.56

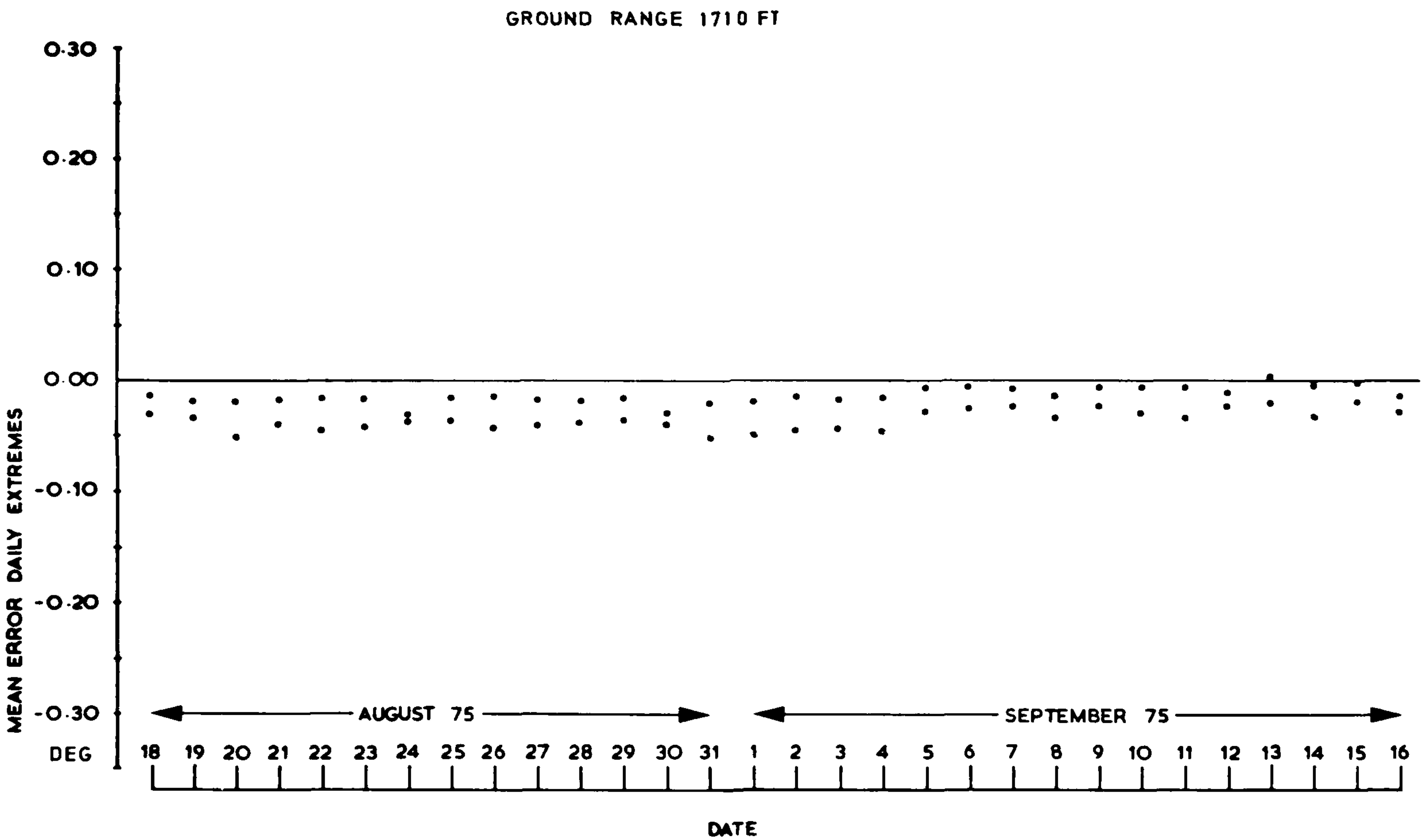


Fig 4.56 Stability test – missed approach azimuth daily mean error extremes

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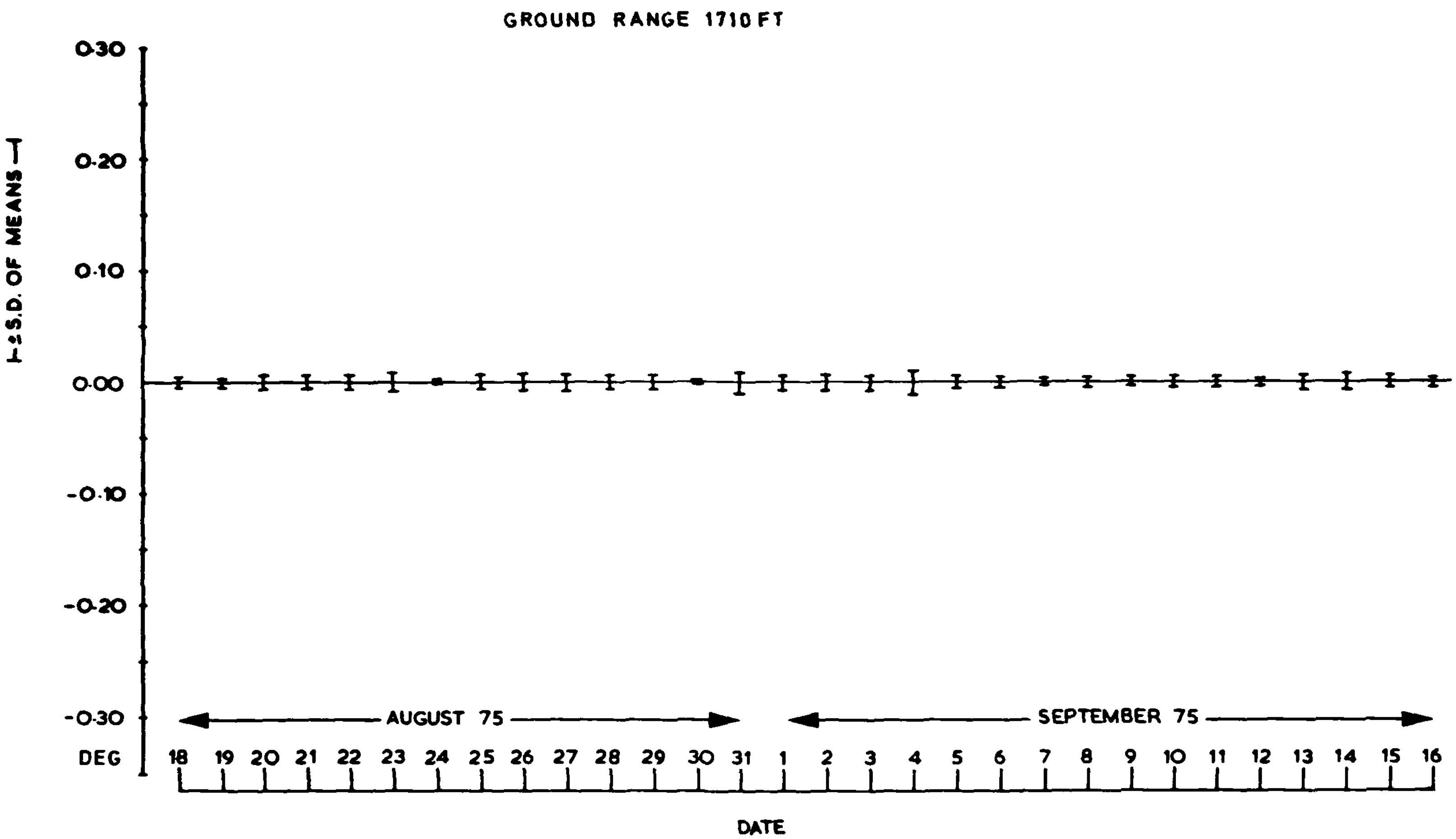


Fig 4.57 Stability test – missed approach azimuth daily standard deviation of means

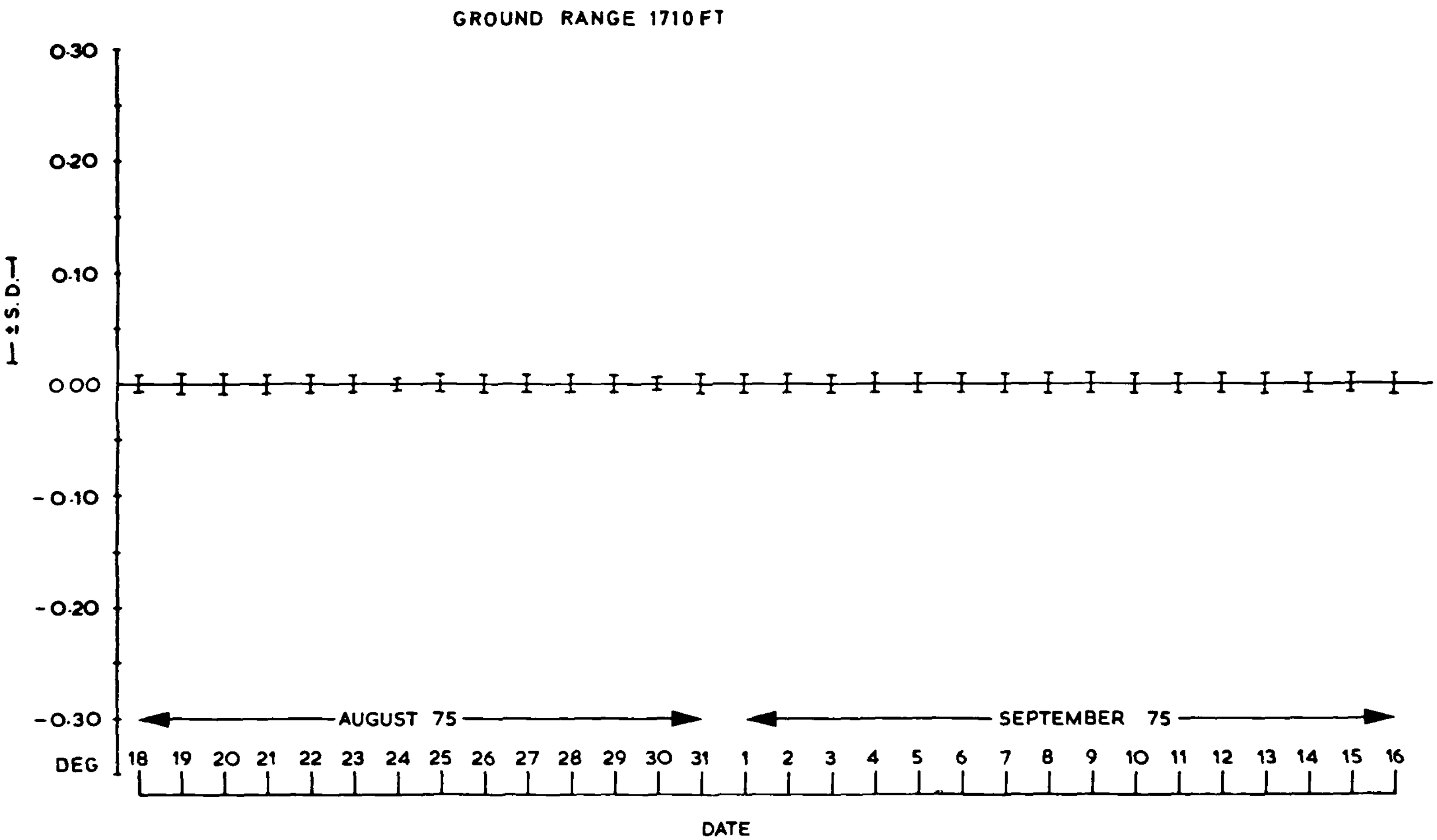


Fig 4.58 Stability test – missed approach azimuth noise error rms

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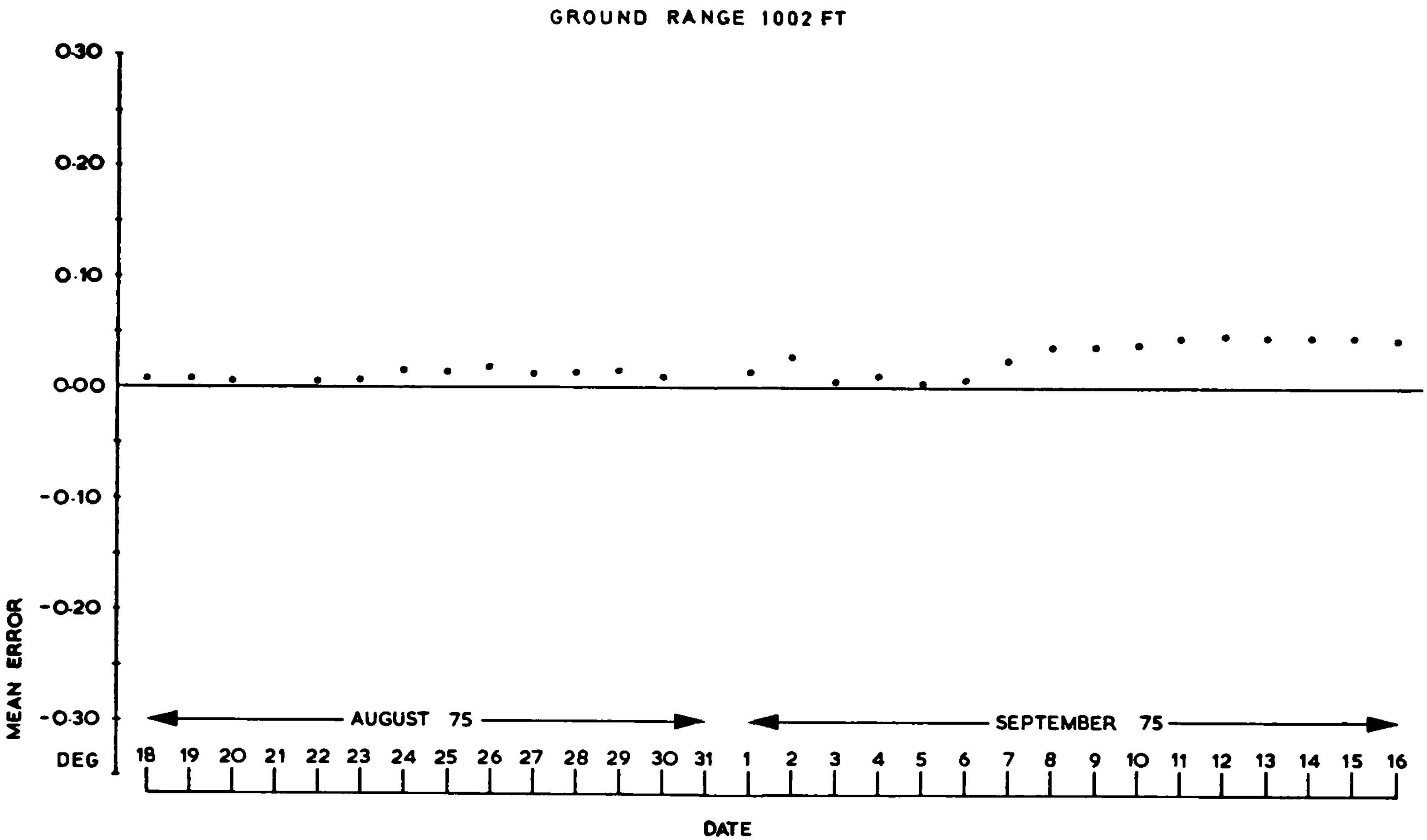


Fig 4.59 Stability test – elevation mean error

Fig 4.60

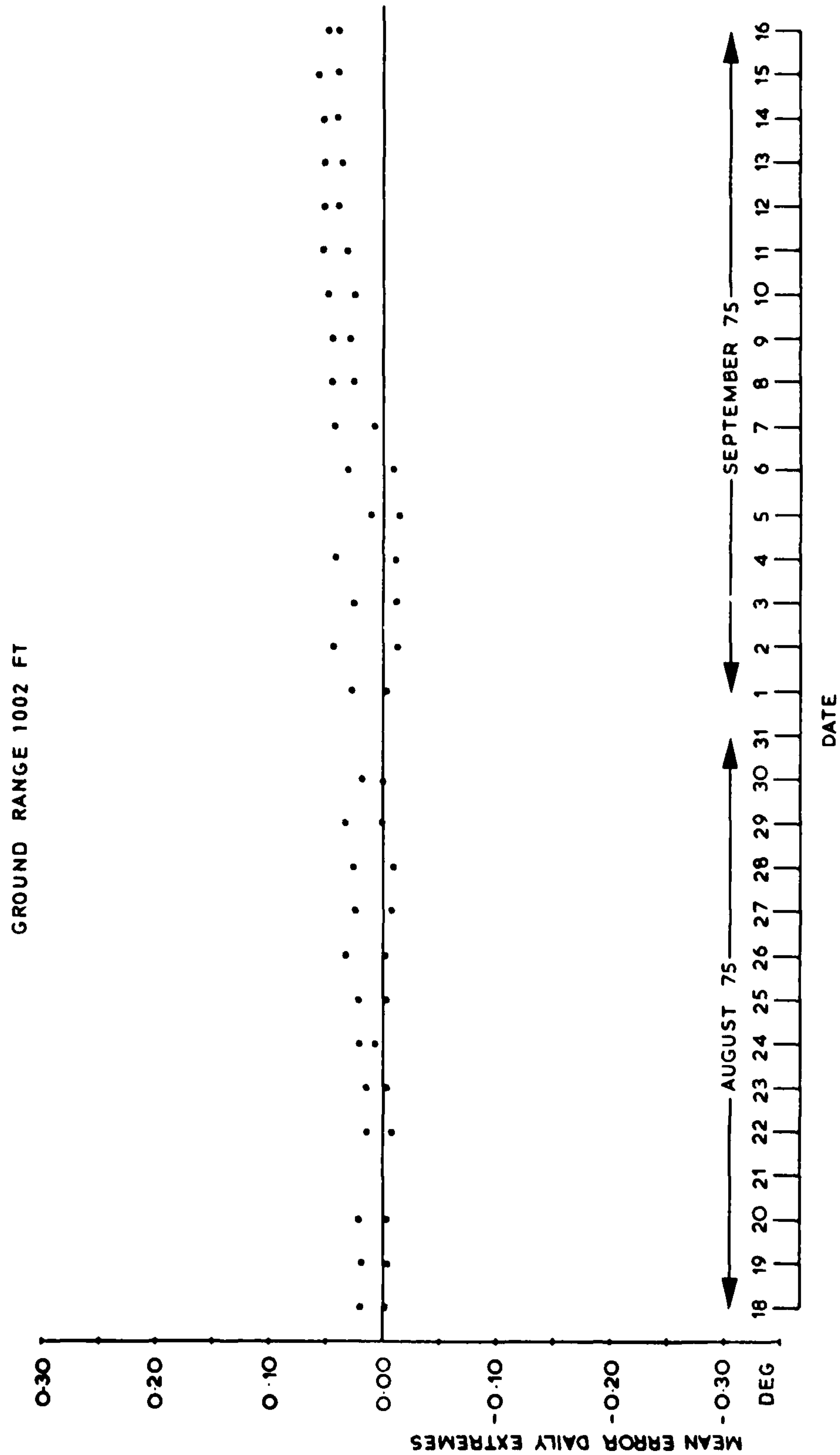


**Fig 4.60 Stability test – elevation daily mean error extremes**

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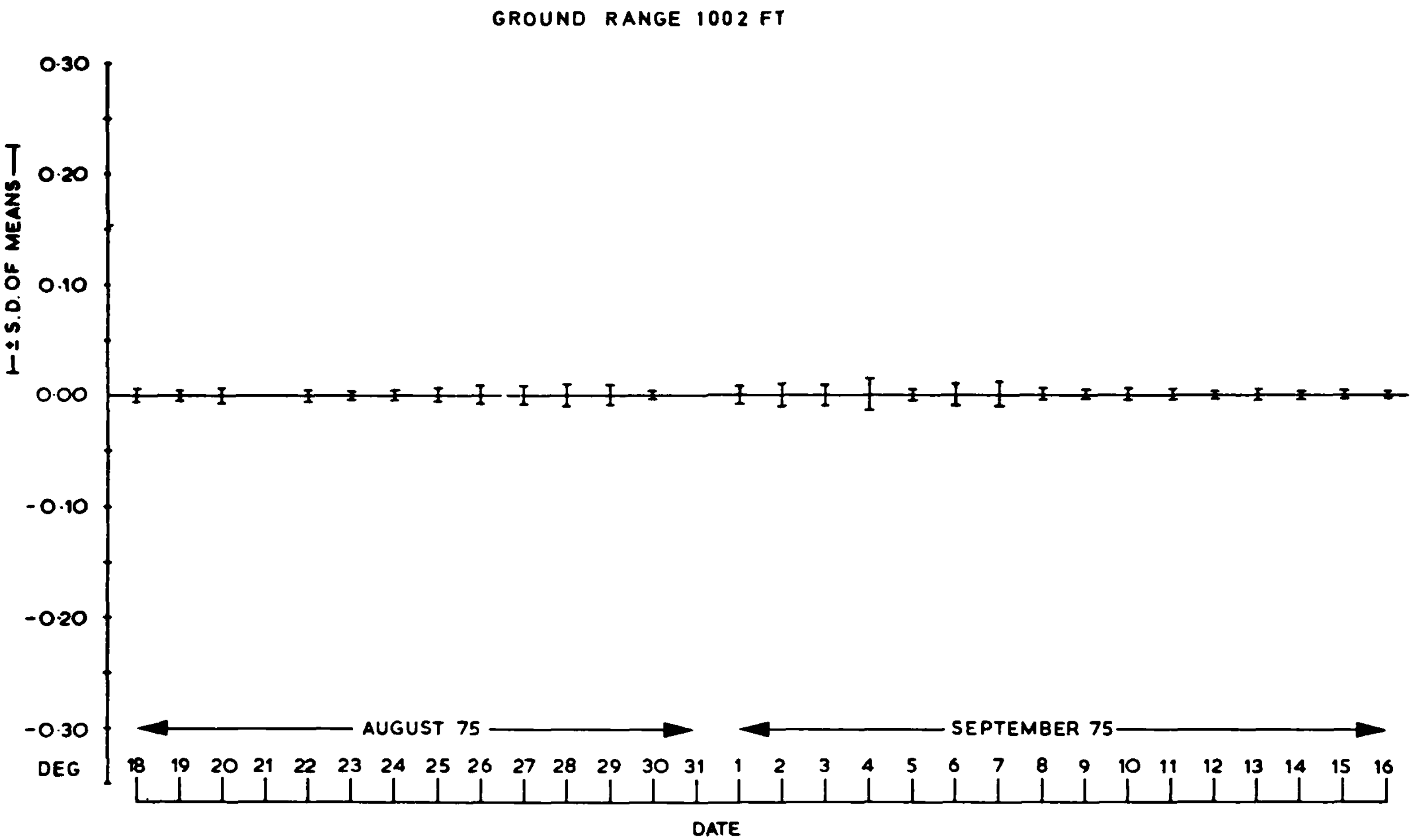


Fig 4.61 Stability test – elevation daily standard deviation of means

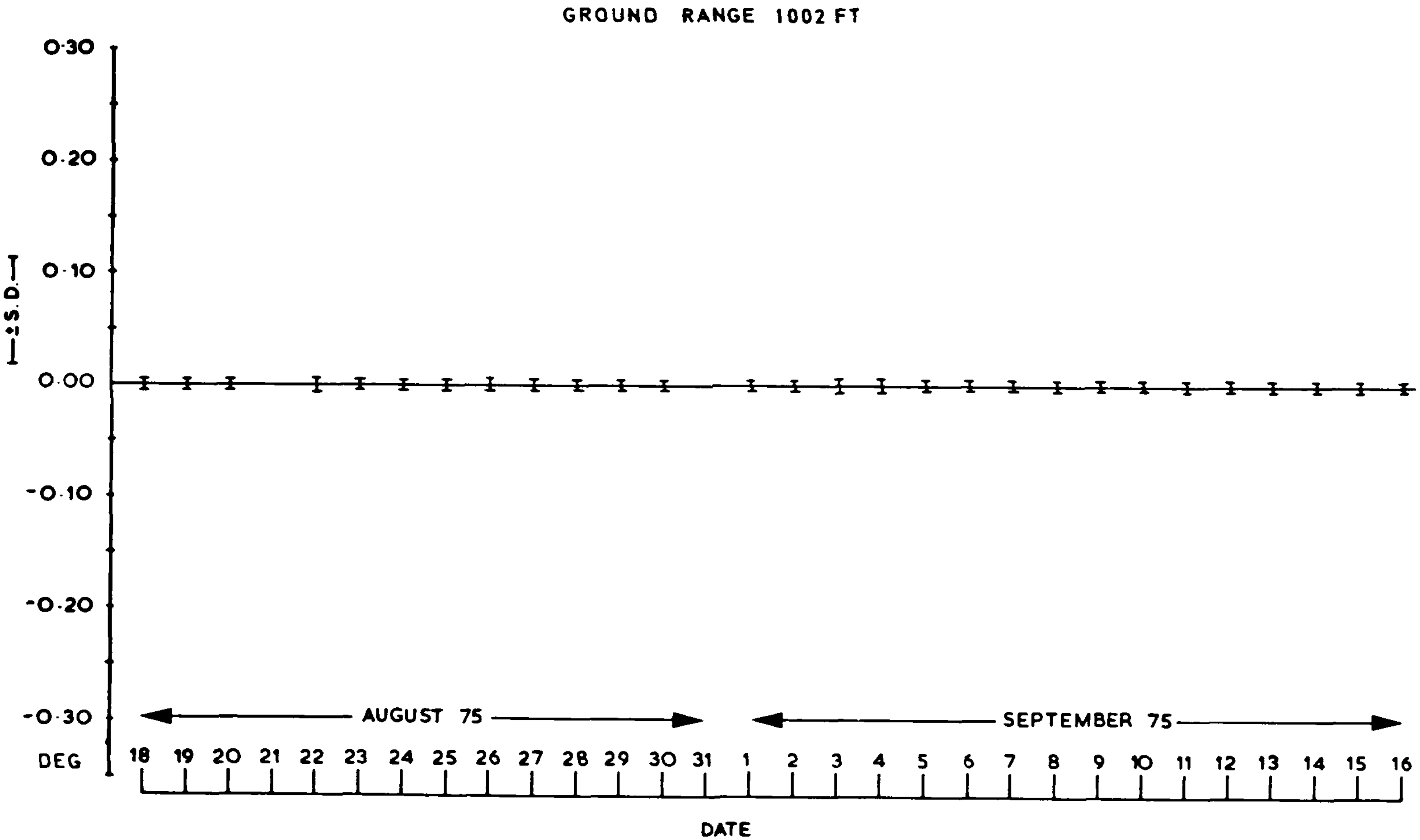


Fig 4.62 Stability test – elevation noise error rms

TR 79052

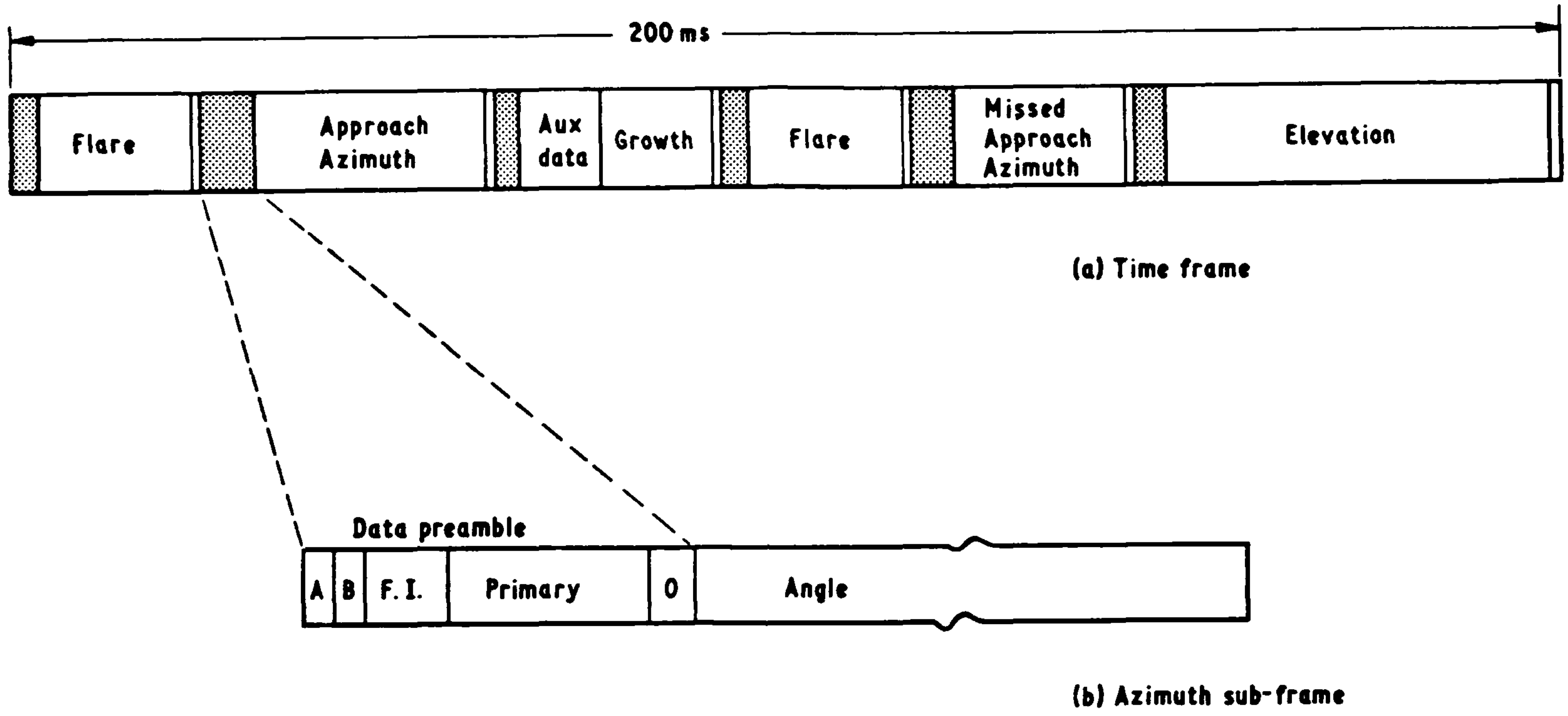


Fig 5.1 TDM signal format

Fig 5.2

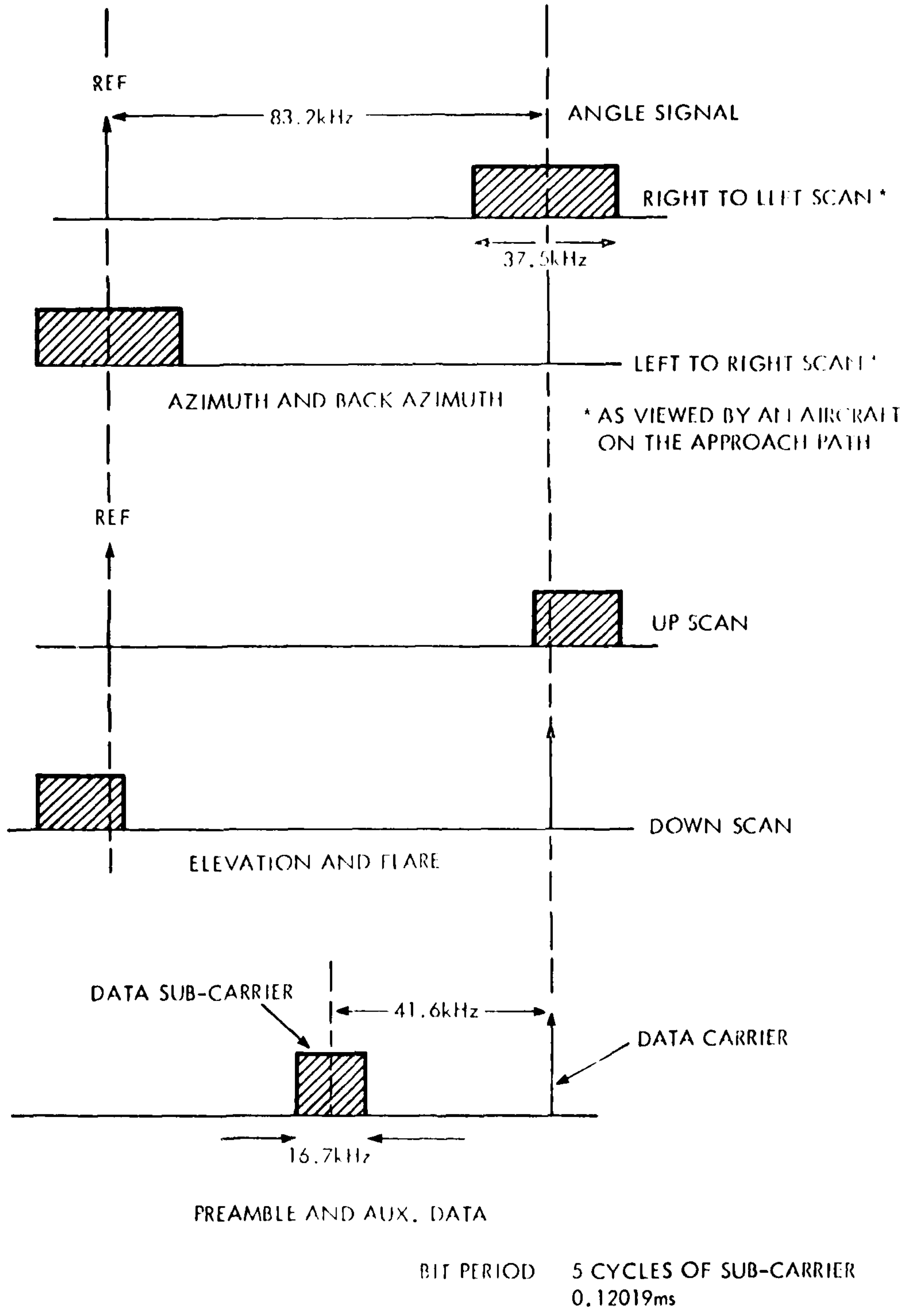


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Fig 5.2 Relative frequencies of the angle and data components of the system

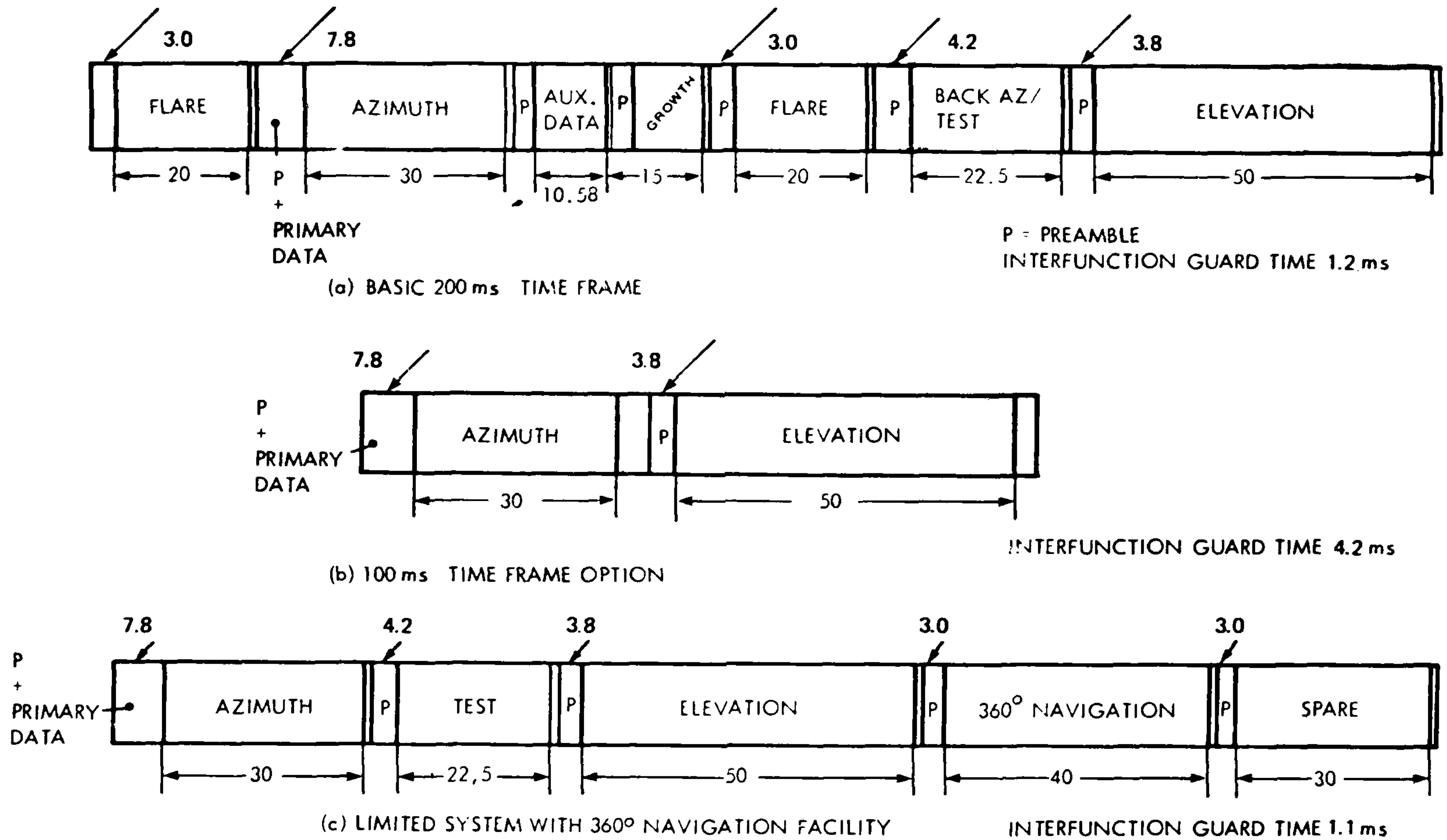


Fig 5.3 Time frame arrangement (major alternatives)

Fig 5.4

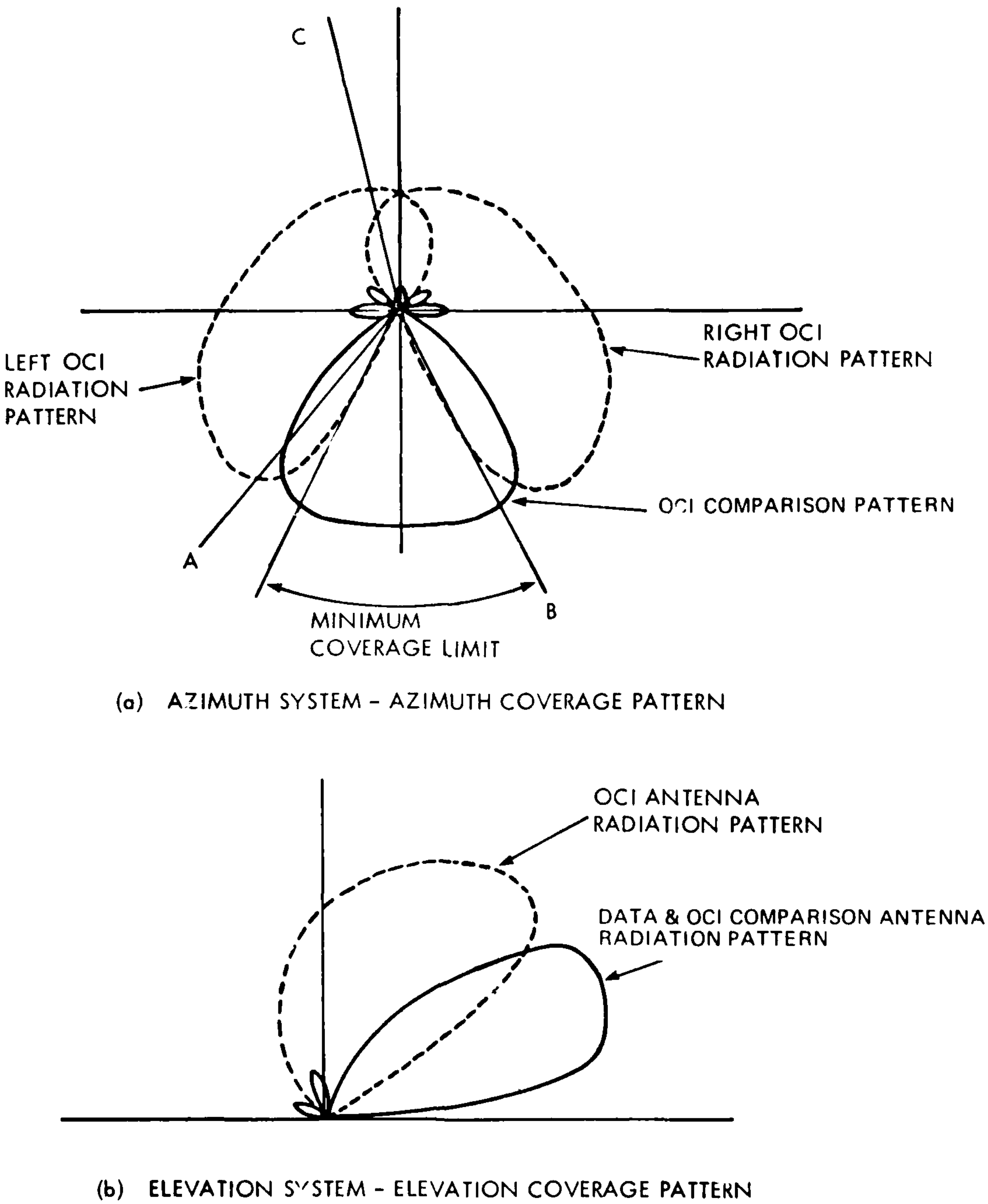


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Fig 5.4 OCI antenna patterns

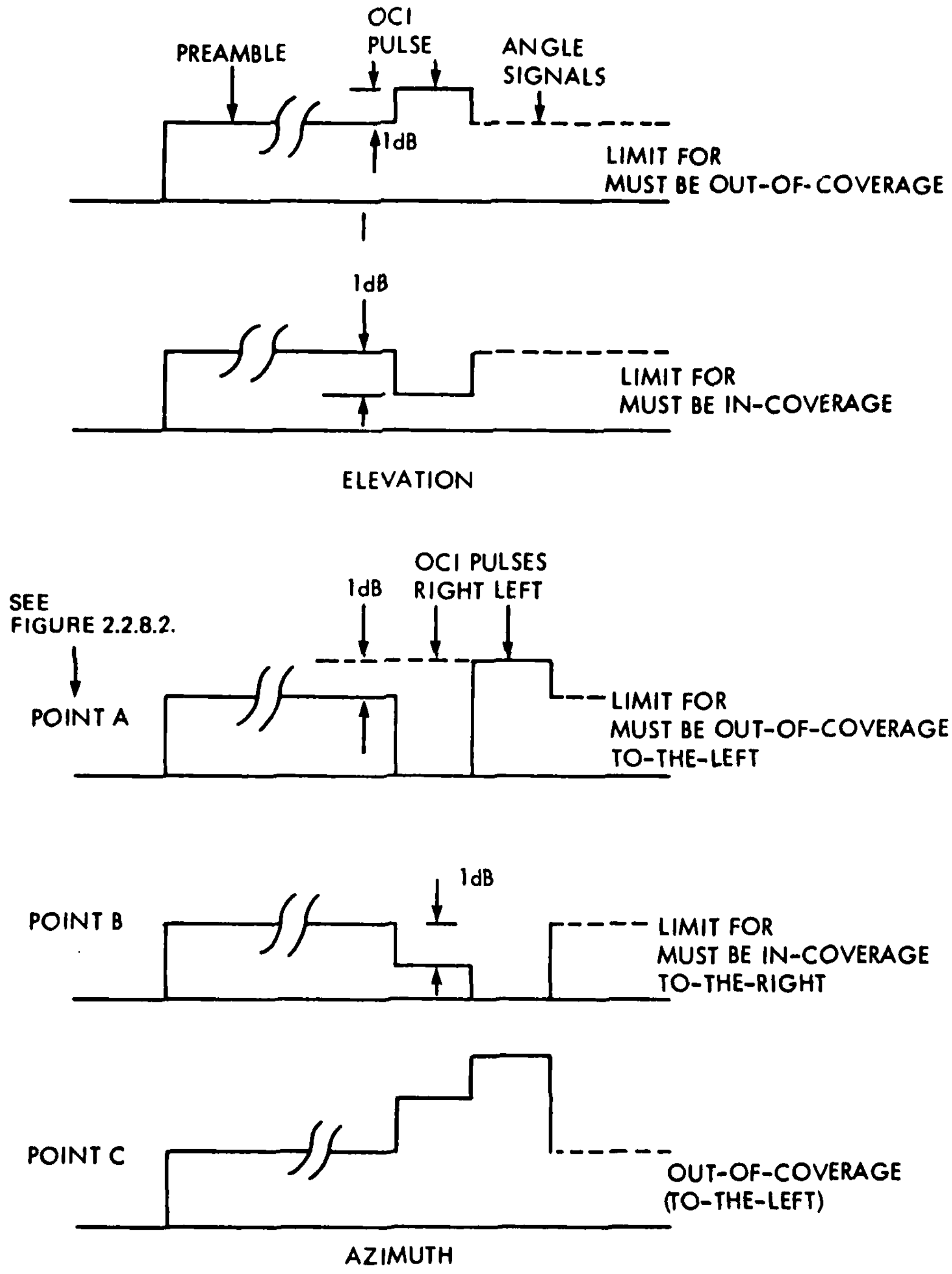


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**Fig 5.5 OCI limits (as seen by the aircraft)**

Fig 5.6

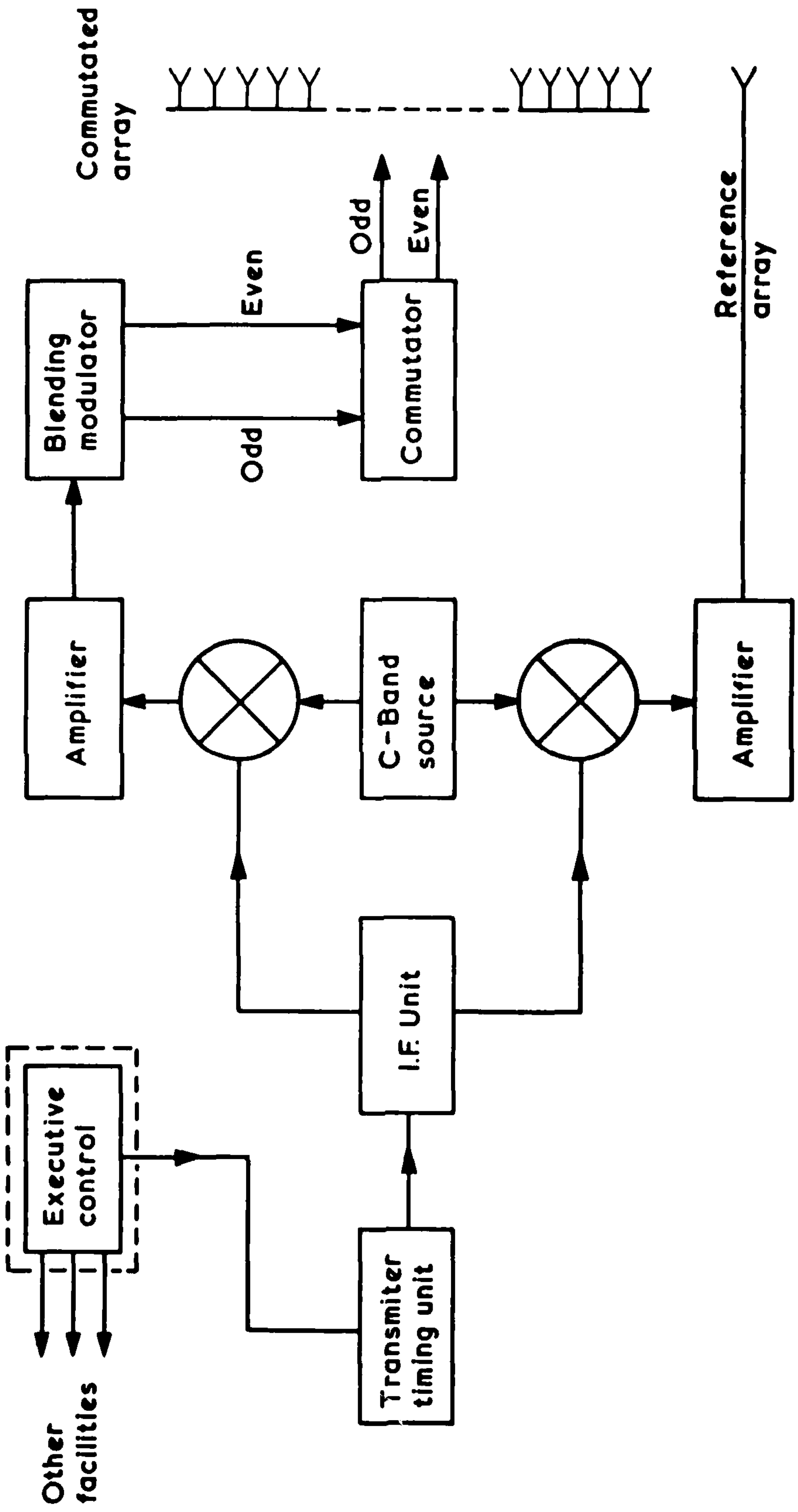


Fig 5.6 Typical ground facility

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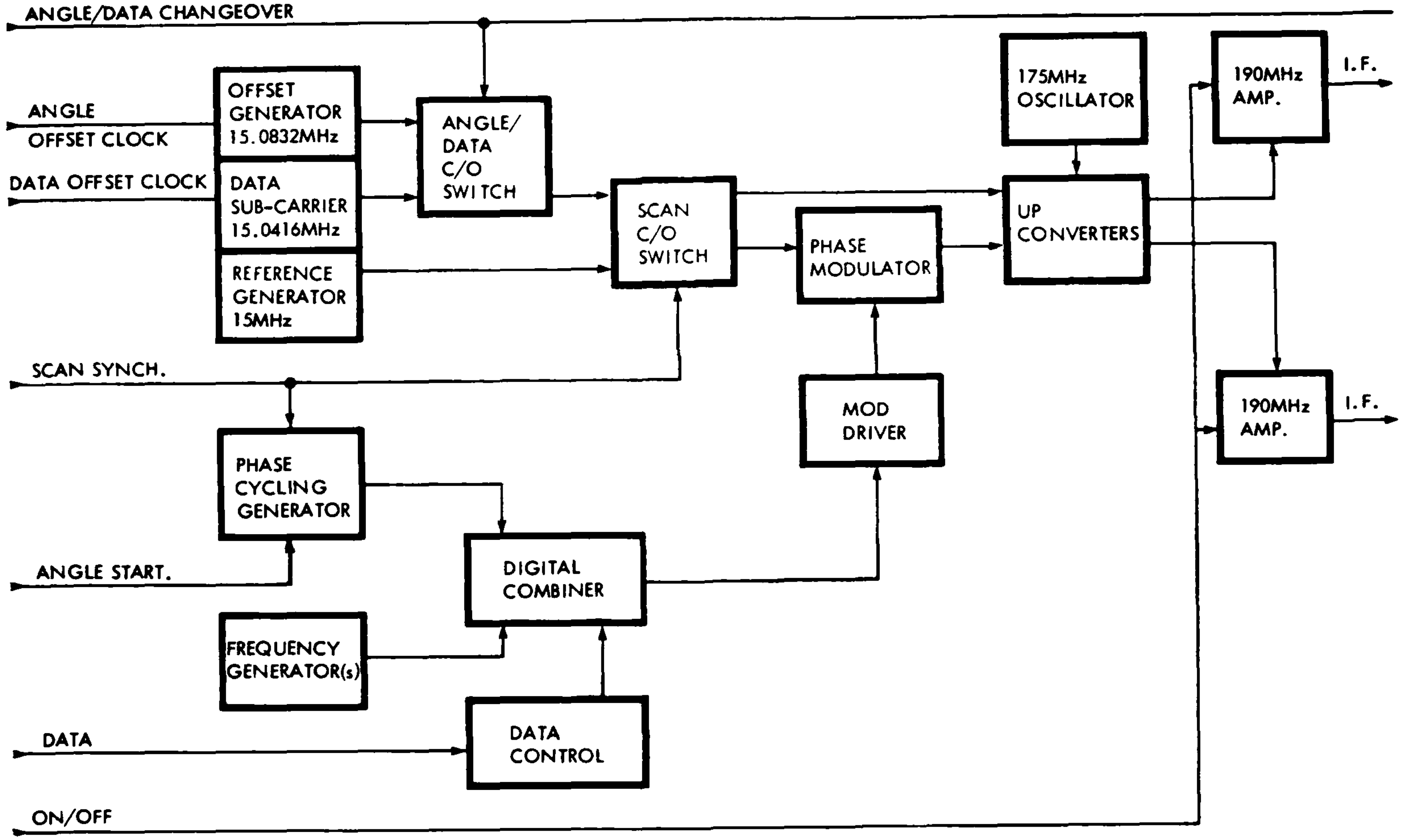


Fig 5.7 Transmitter IF unit

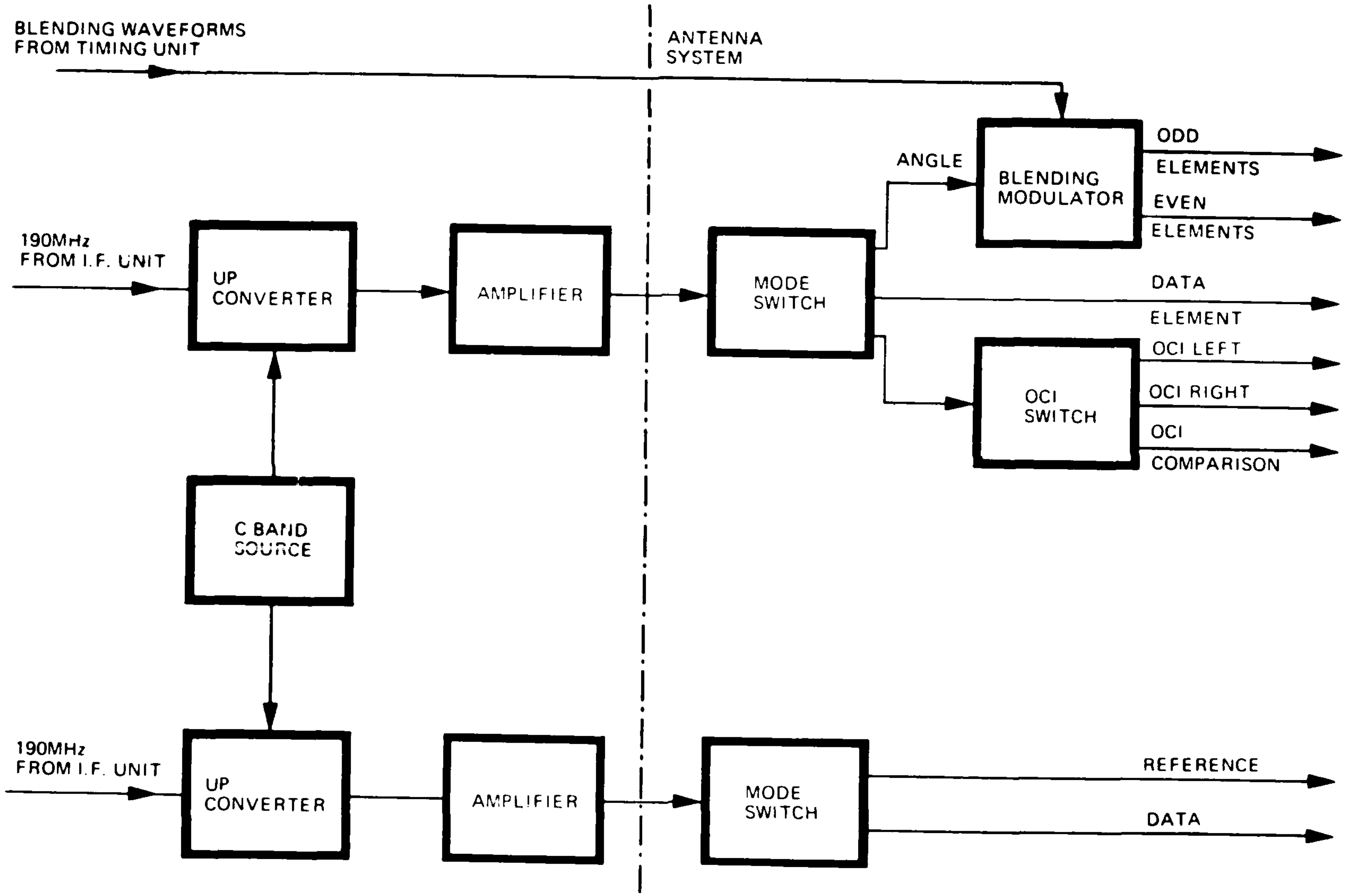


Fig 5.8 Transmitter and antenna RF

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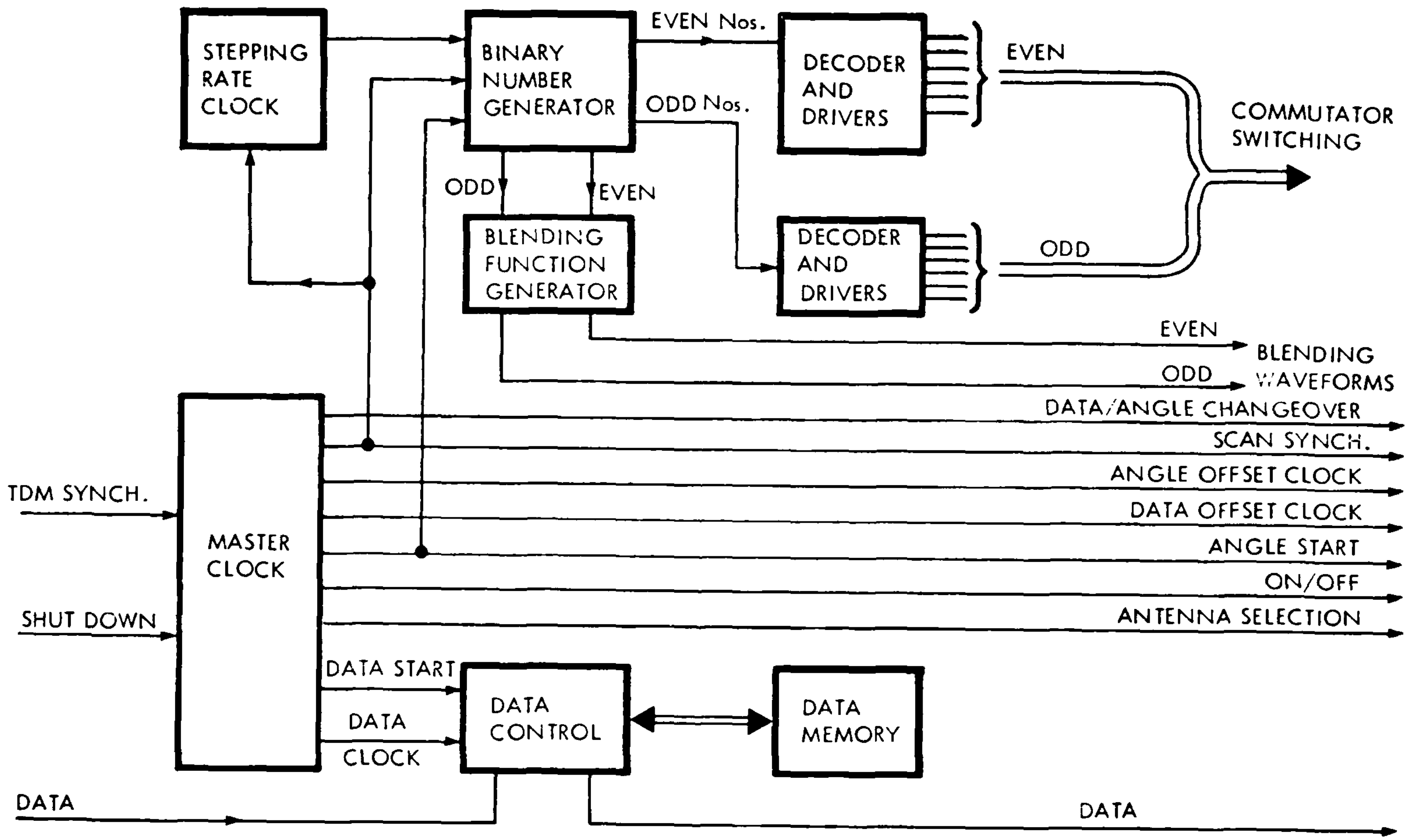


Fig 5.9 Transmitter timing unit

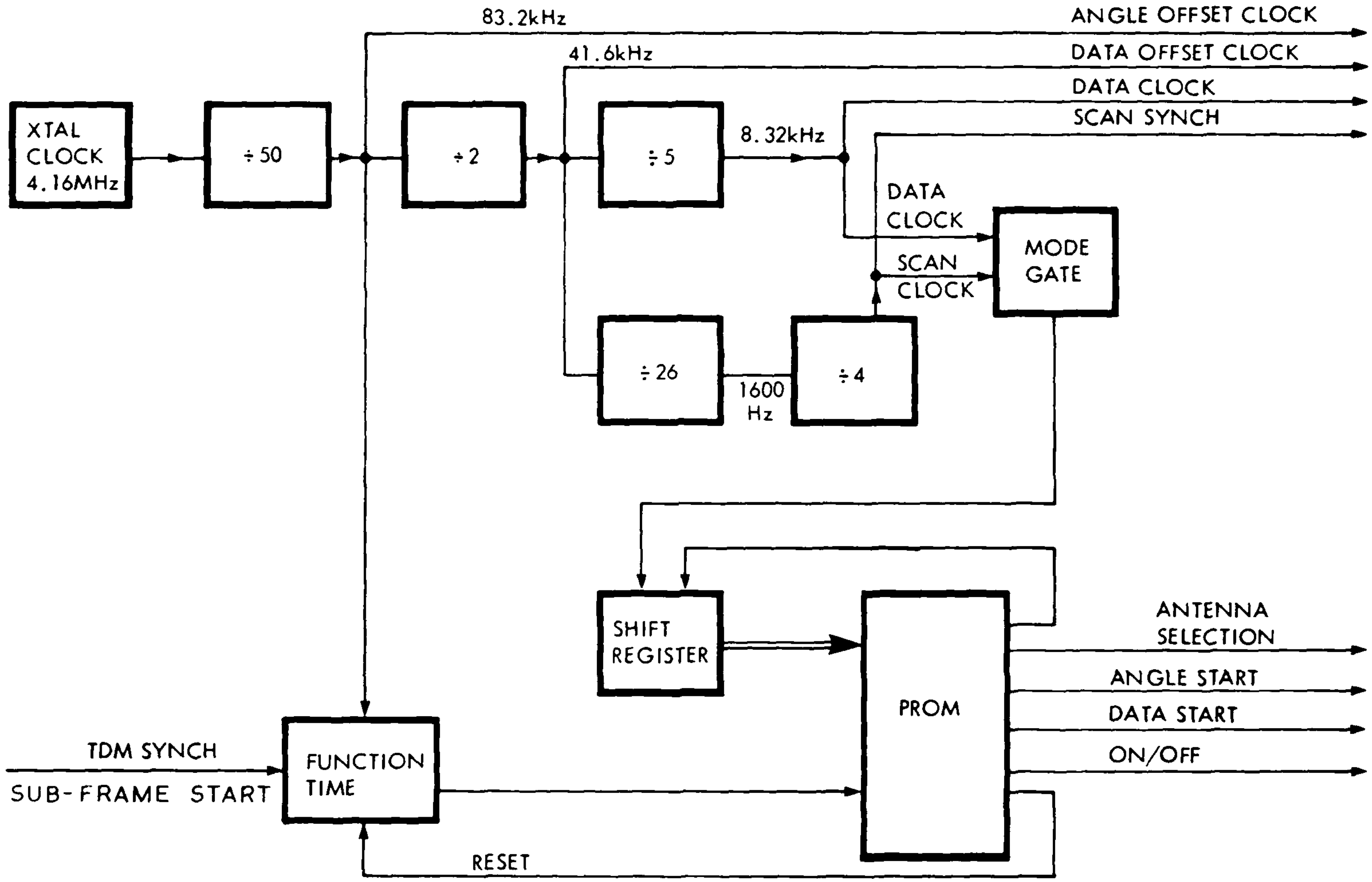


Fig 5.10 Master clock

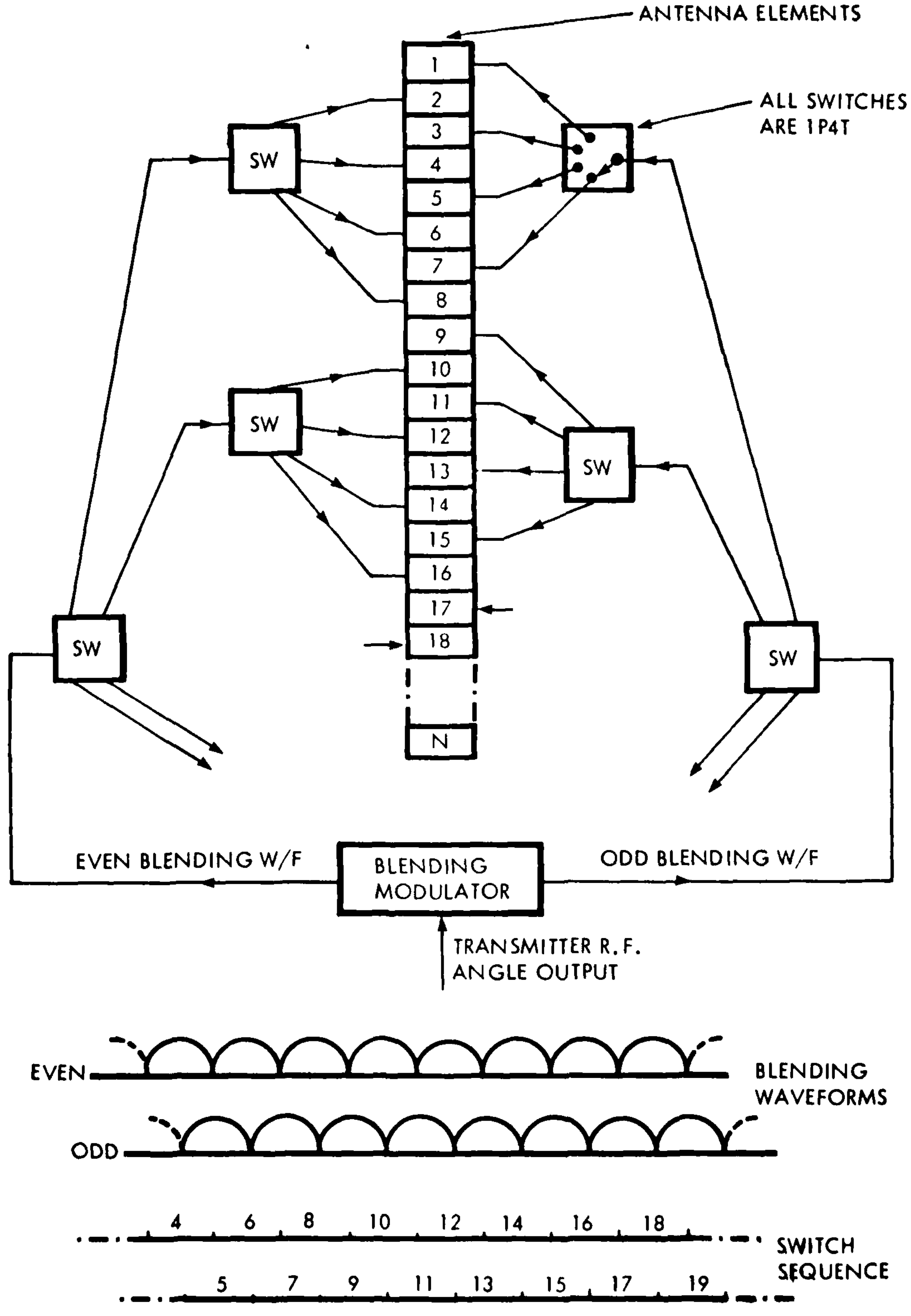


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Fig 5.11 Commutator switching

Fig 5.12

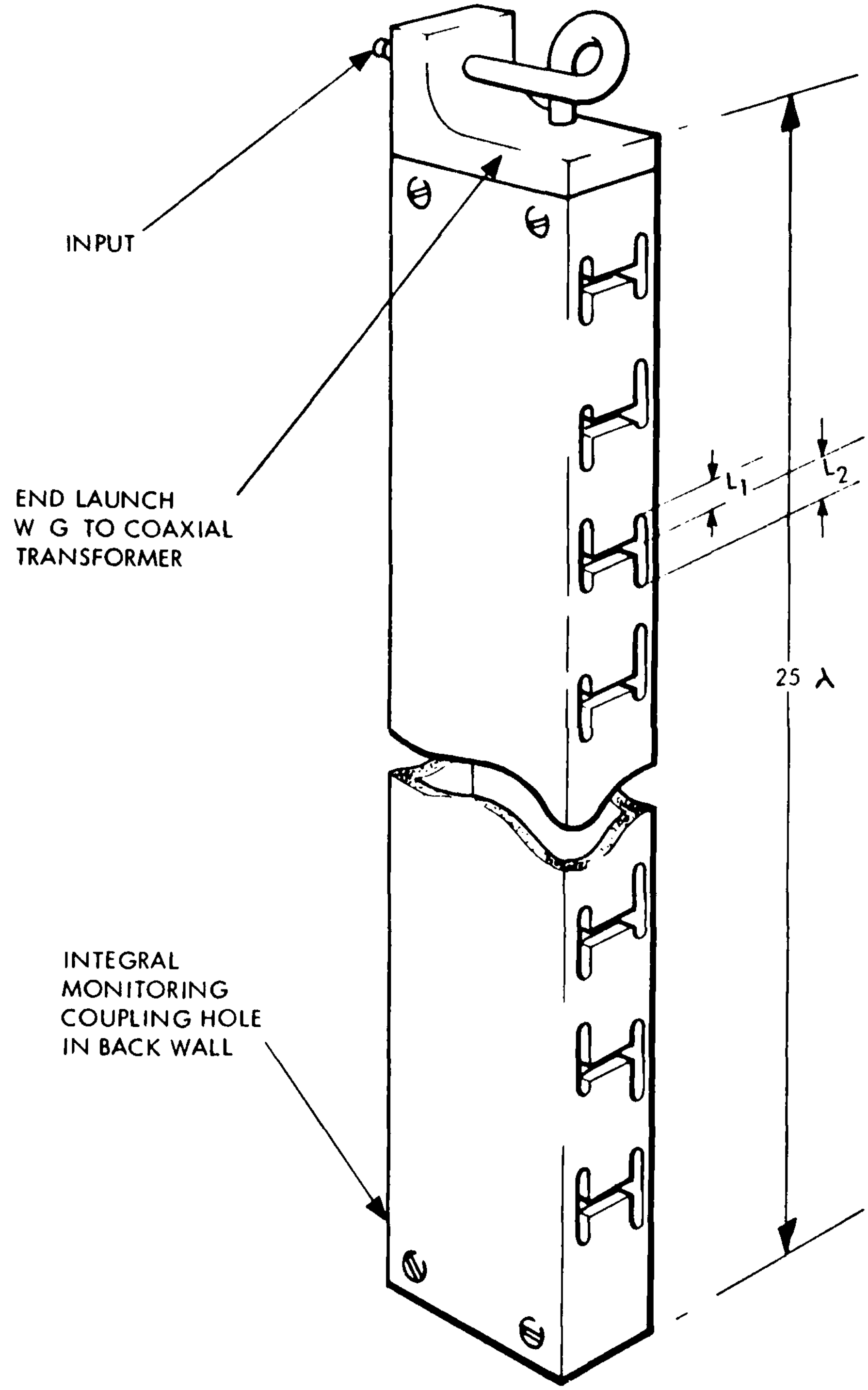


**Fig 5.12 Azimuth vertical column element**

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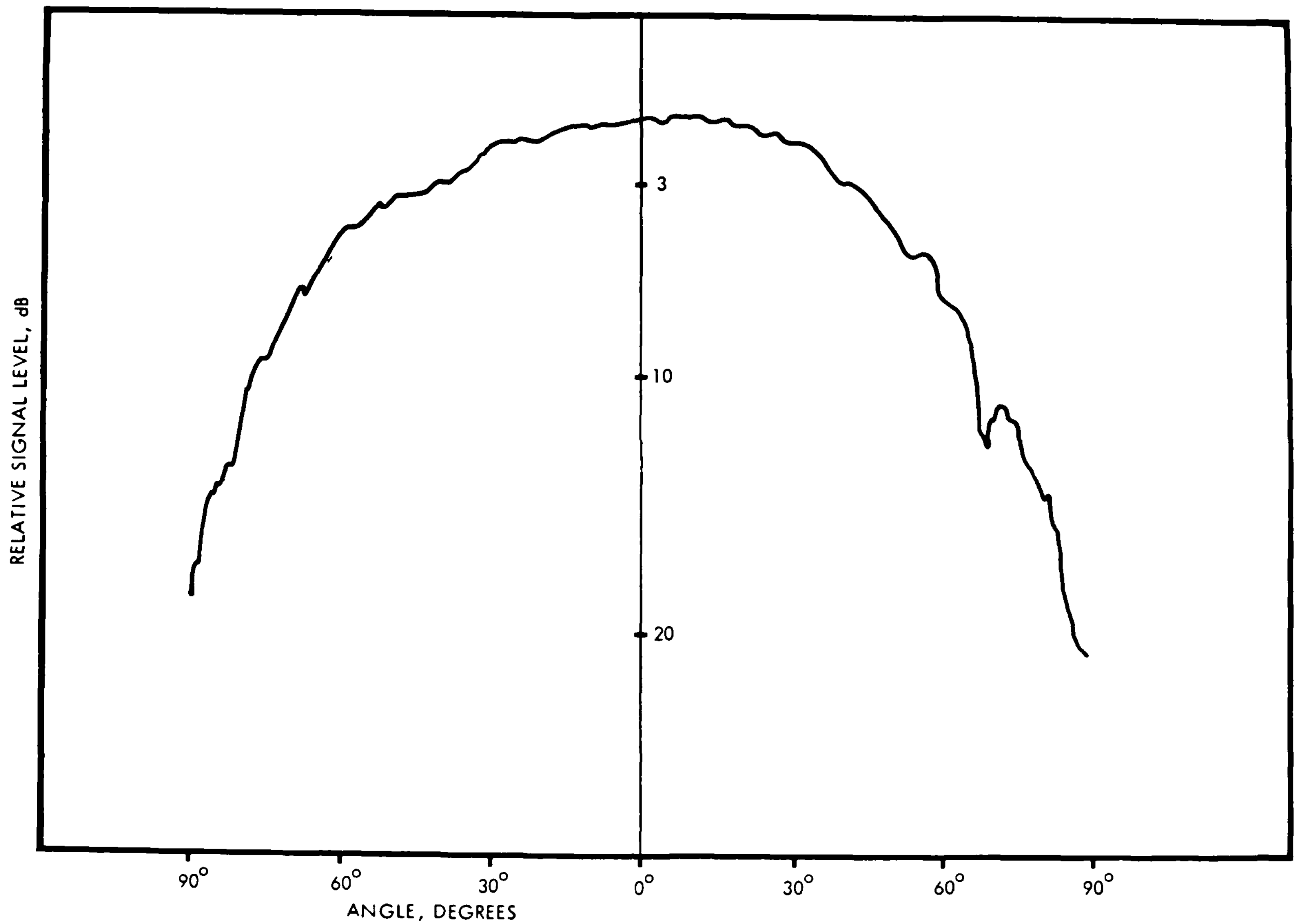


**Fig 5.13 Azimuth array — typical azimuth radiation pattern**

Fig 5.14

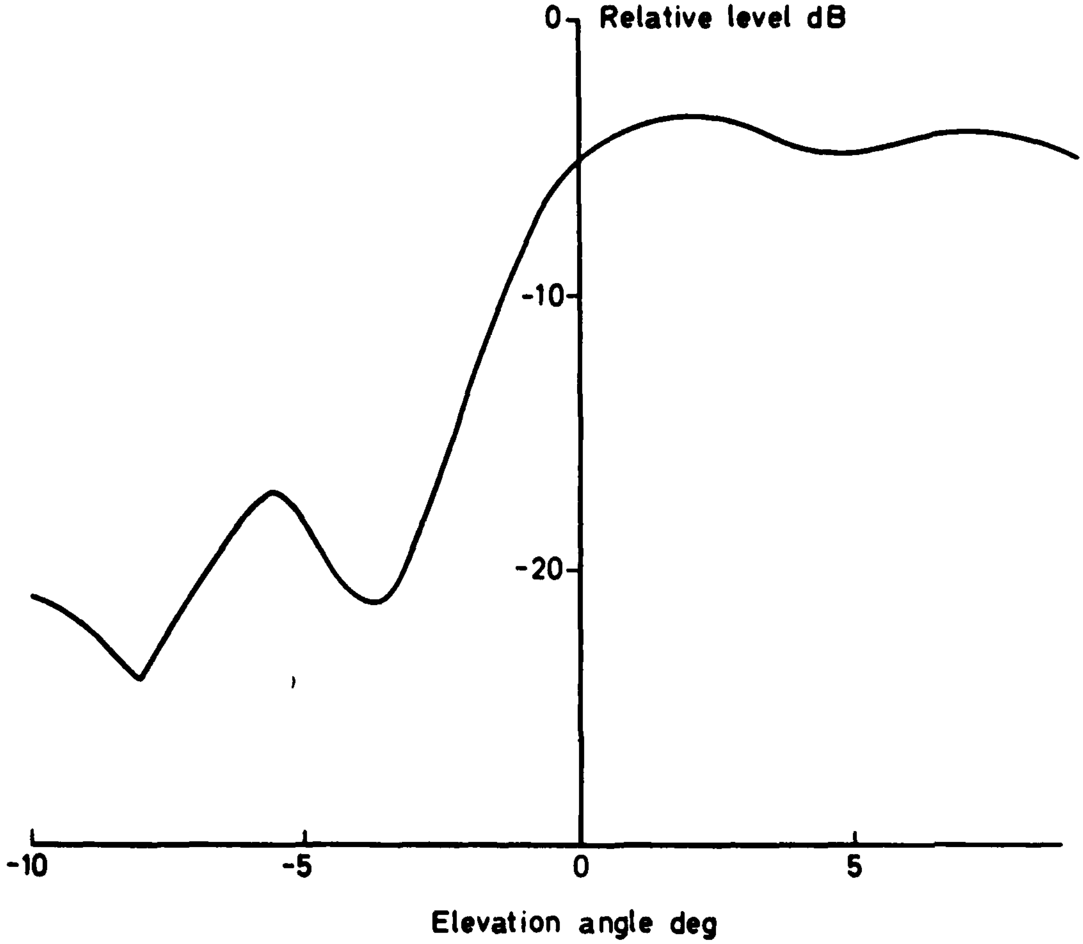


Fig 5.14 Column element typical vertical radiation pattern

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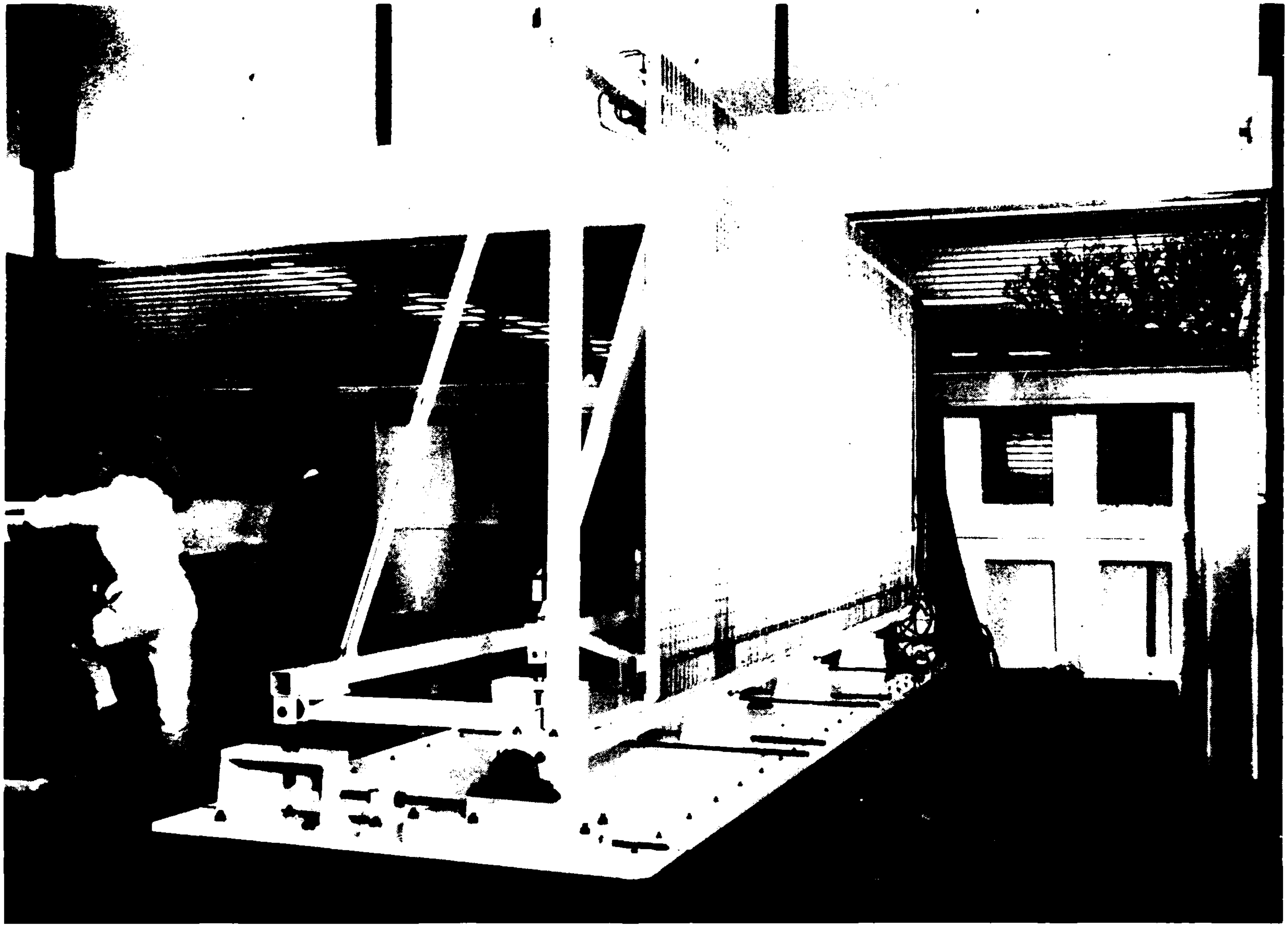

Fig 5.15 Azimuth array showing slotted columns and support frame

Fig 5.16

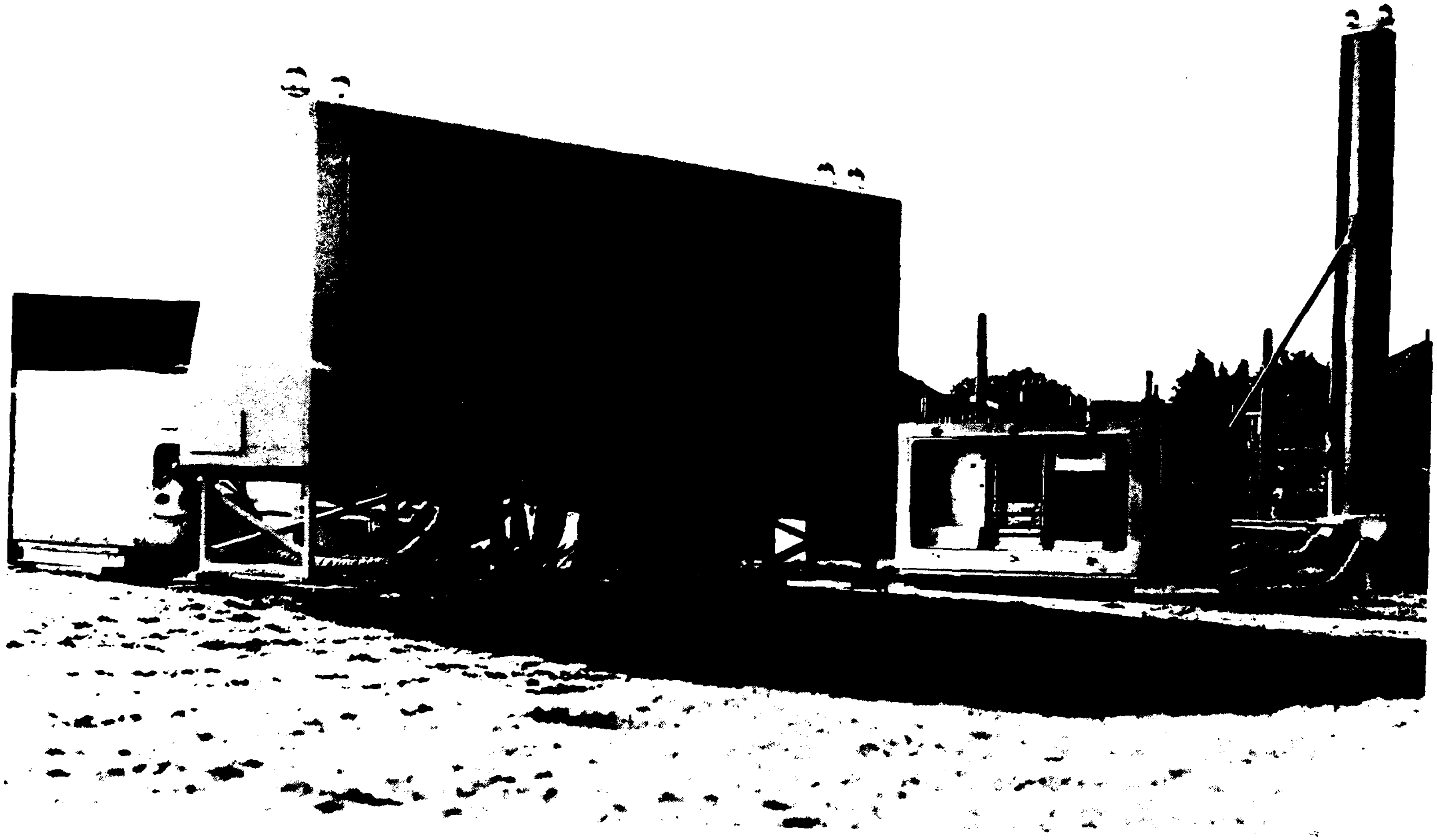

Fig 5.16 Collocated elevation and azimuth arrays

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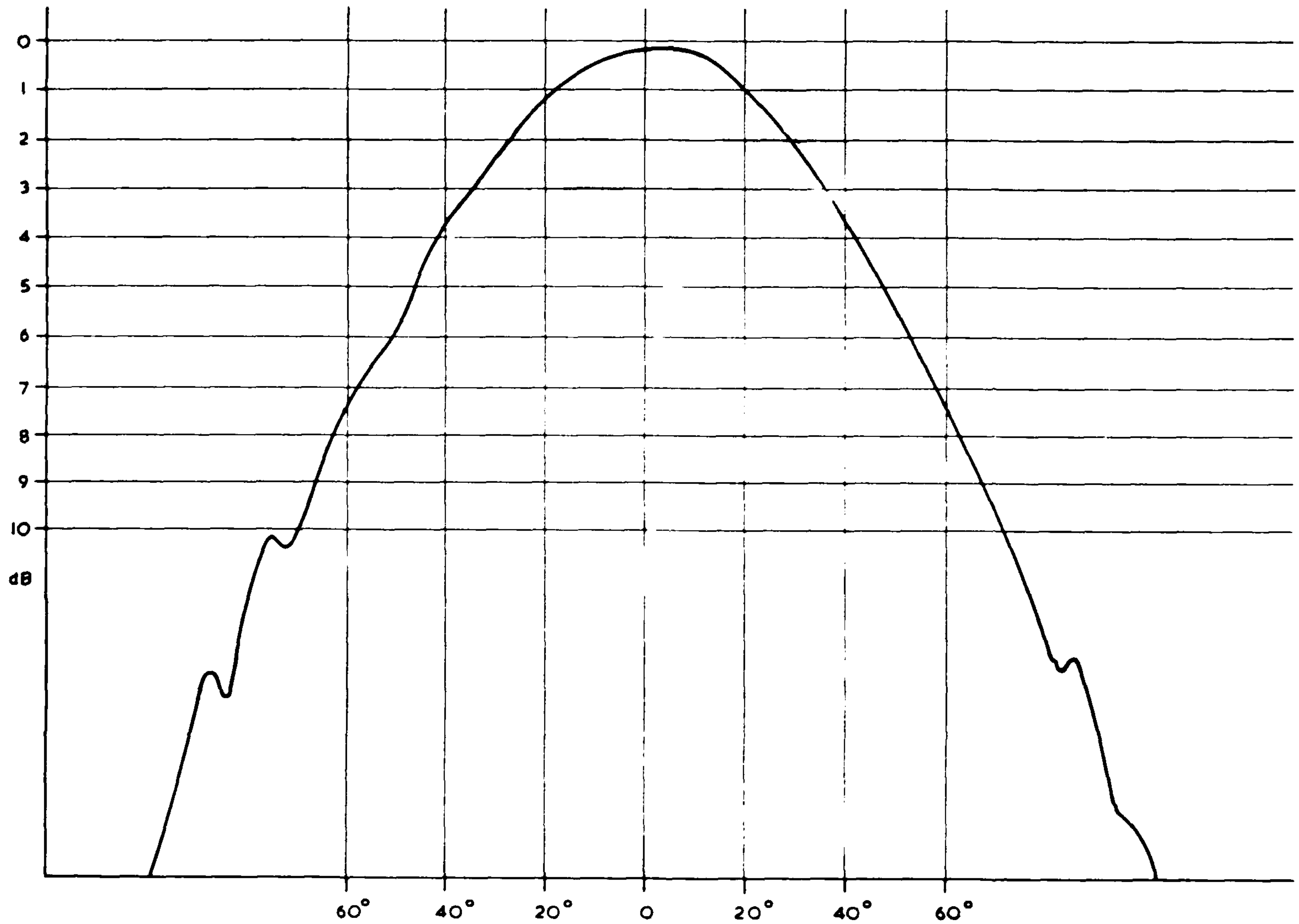


Fig 5.17 Elevation array element – azimuth radiation pattern

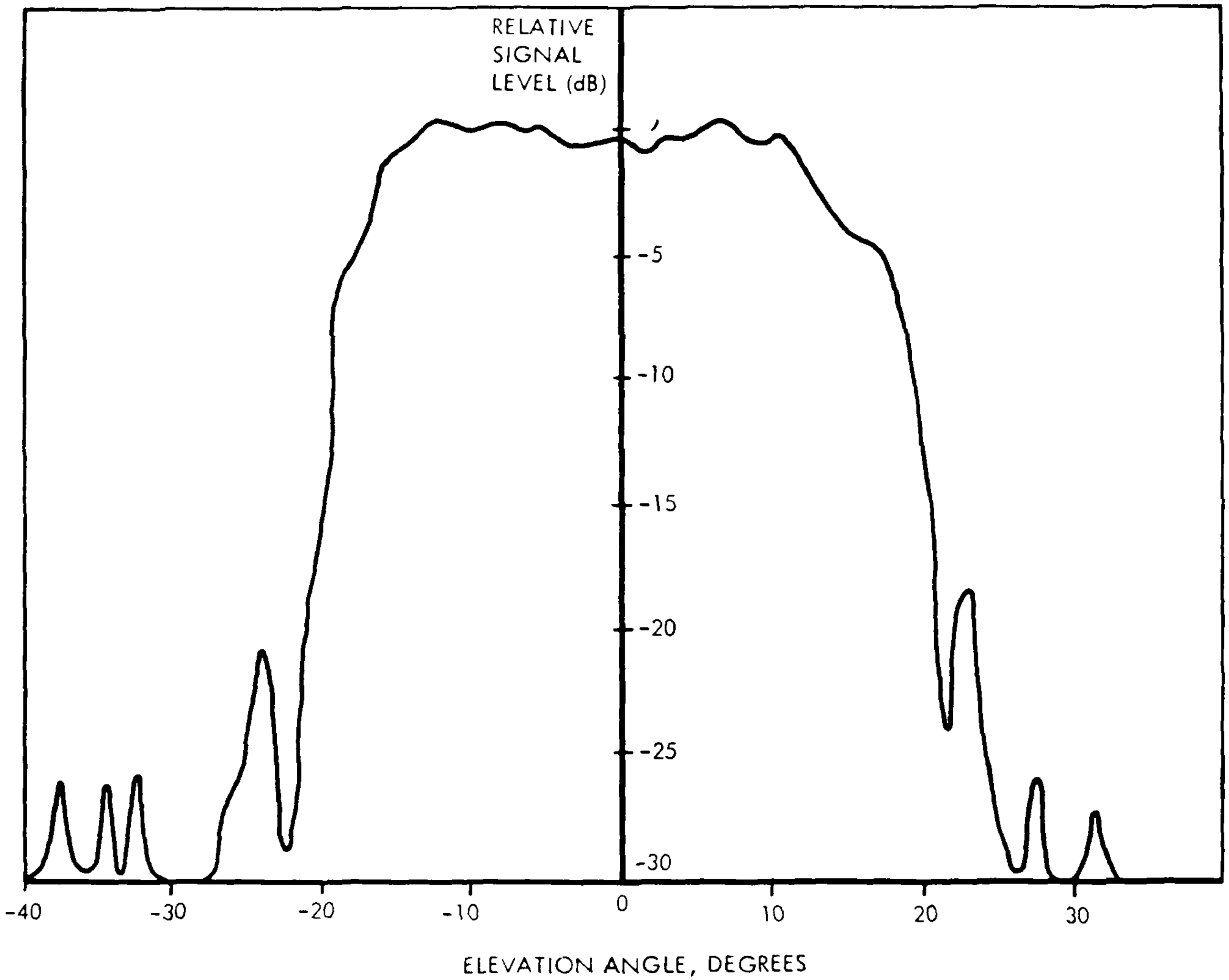


Fig 5.18 Elevation array element – elevation radiation pattern

Fig 5.19 Completed 54 wavelength GRP elevation array

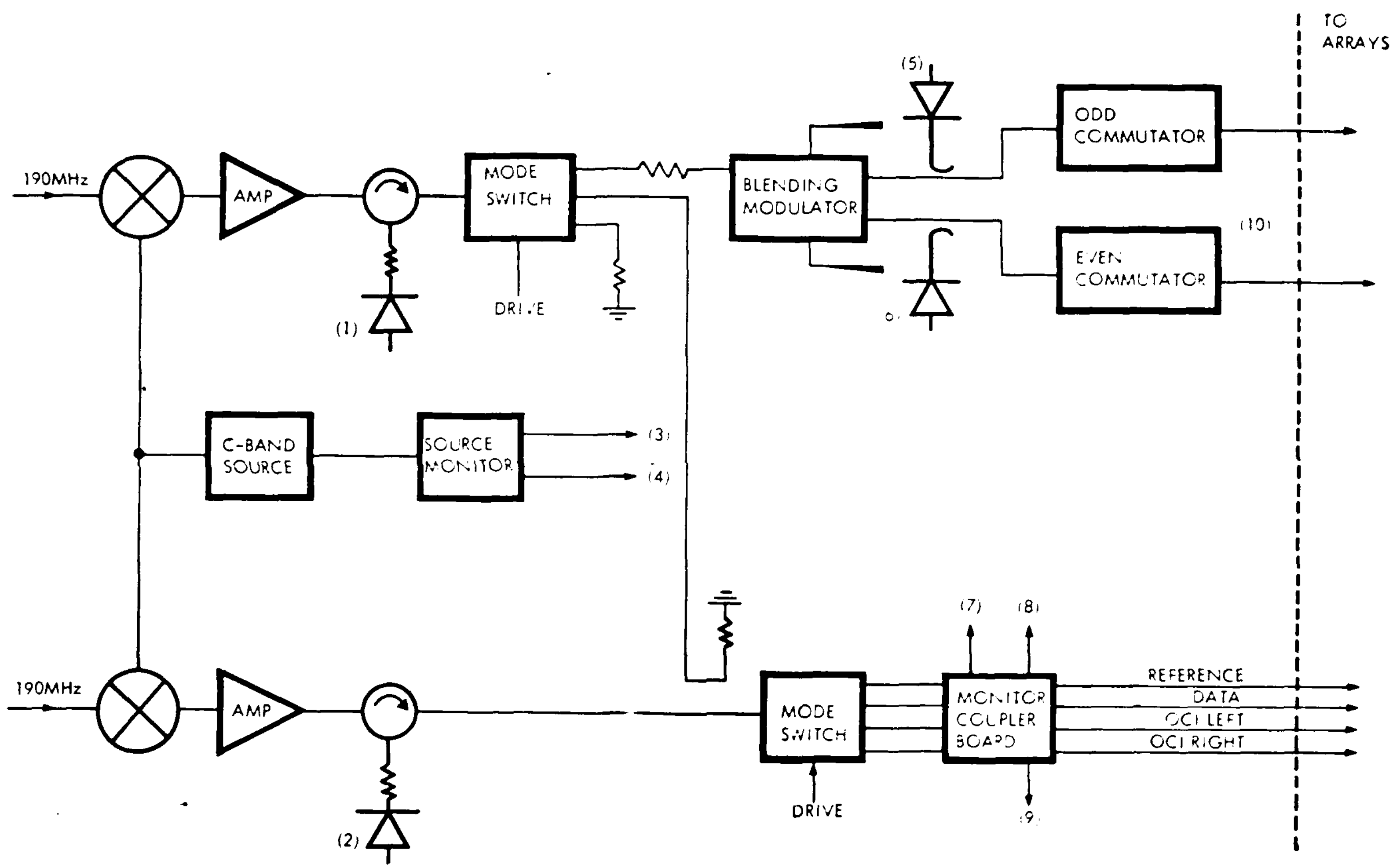


Fig 5.20 Internal monitor – azimuth facility

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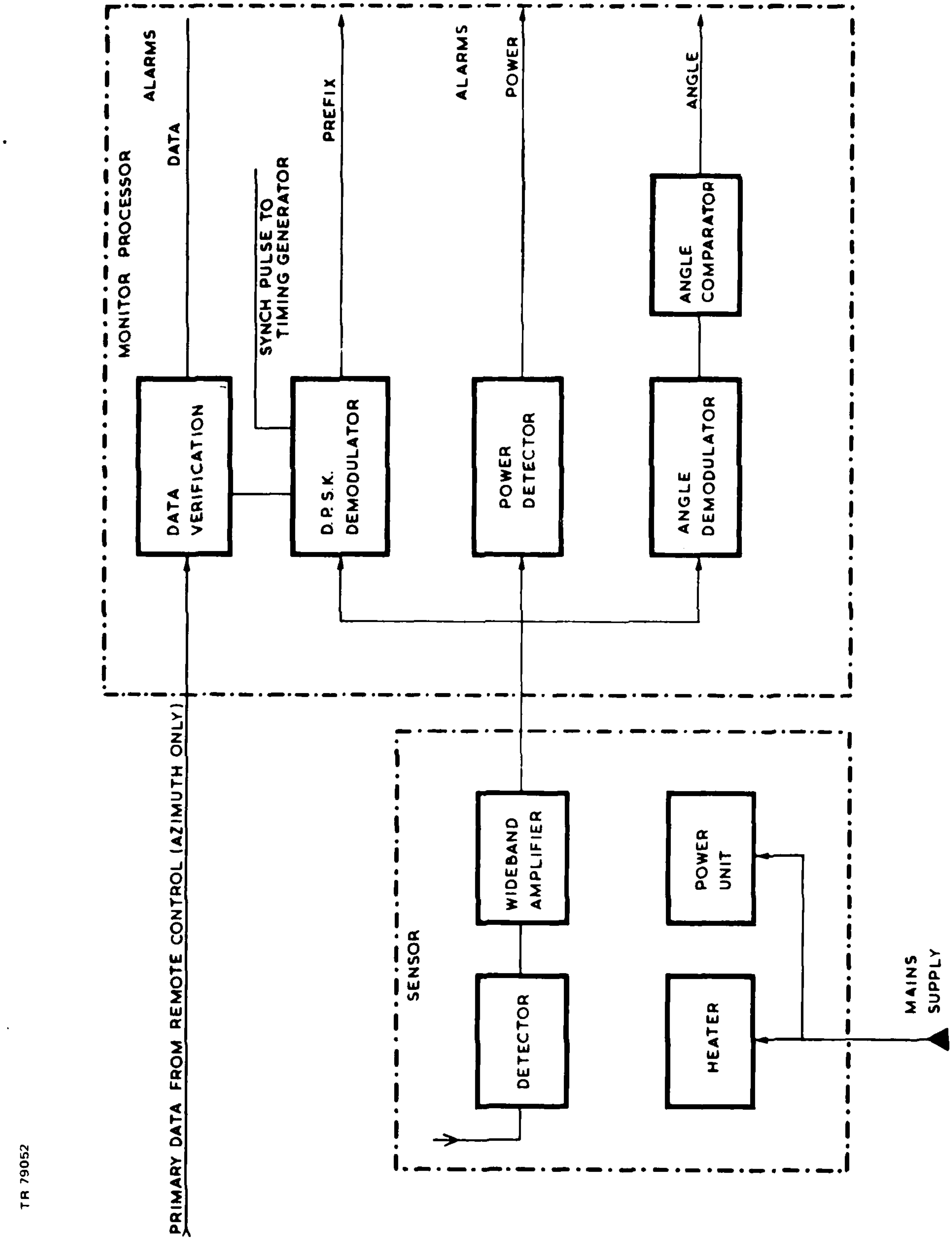


**Fig 5.21 Integral monitor**

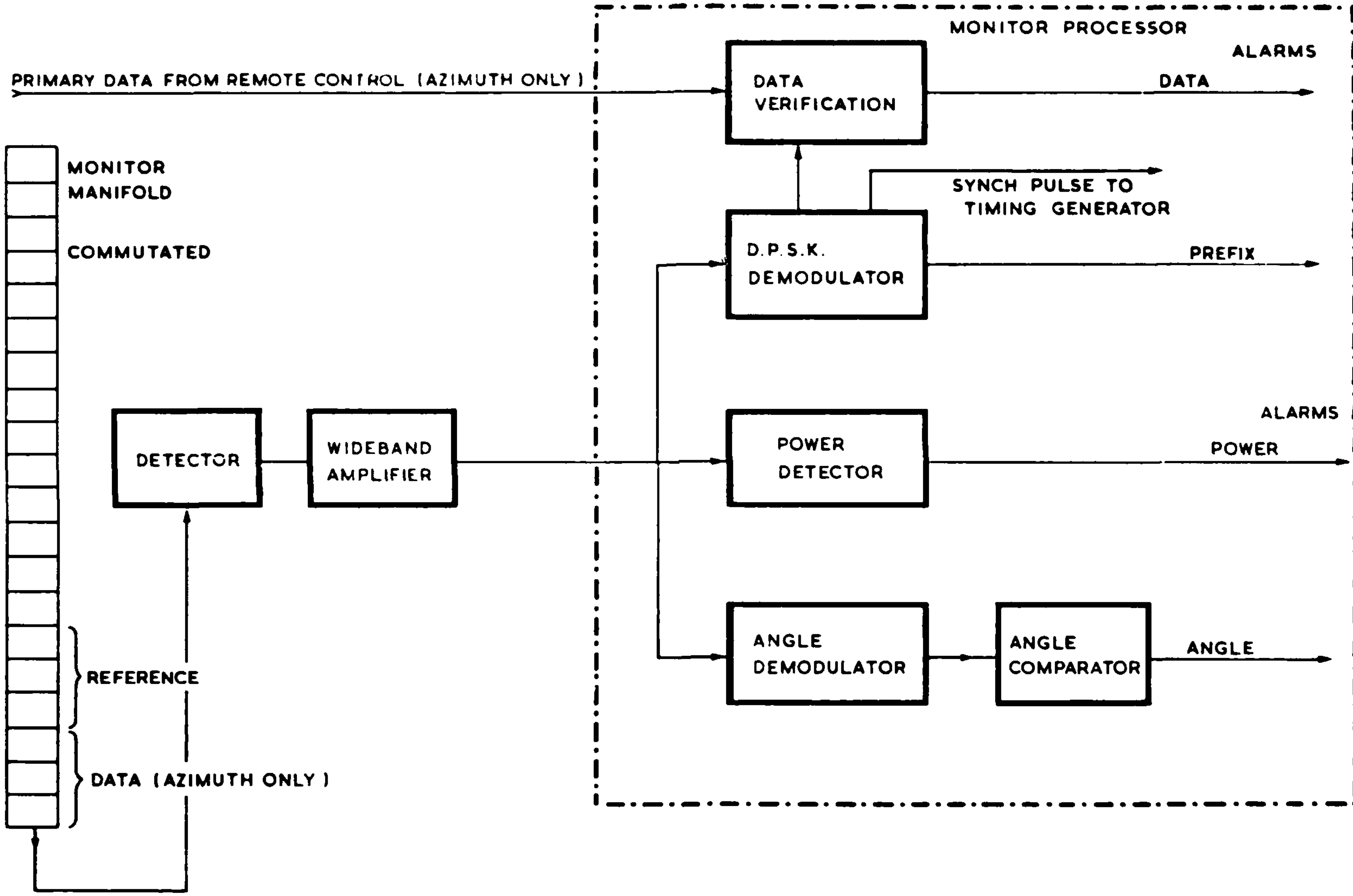


Fig 5.22 Field monitor

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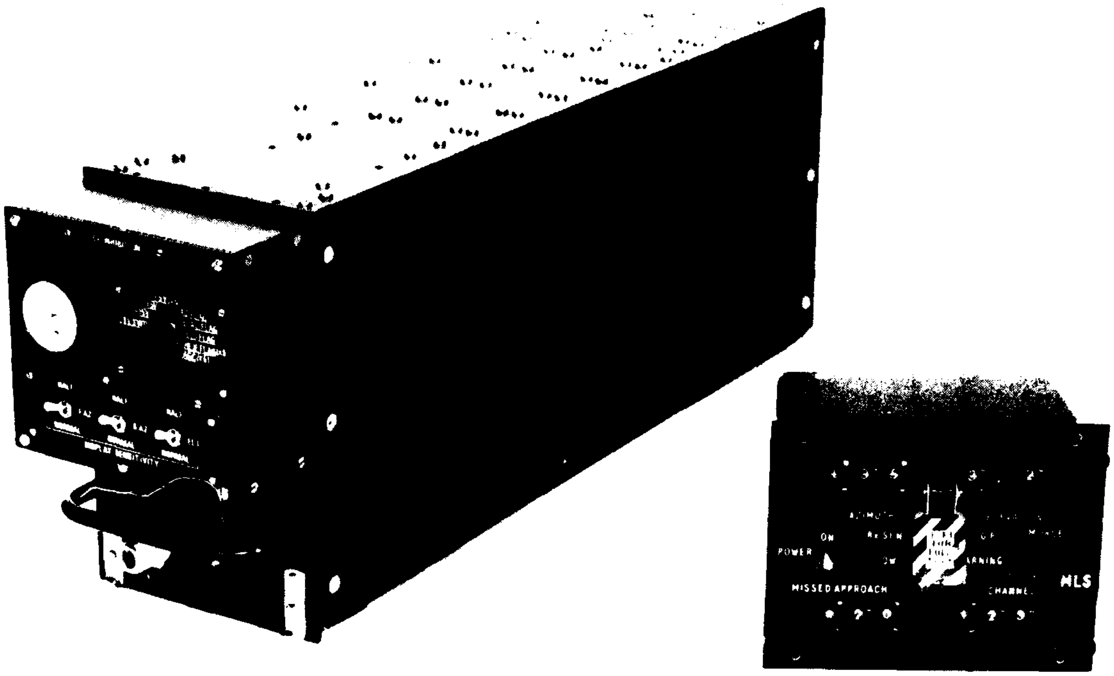


Fig 5.23a Full capability receiver and control unit

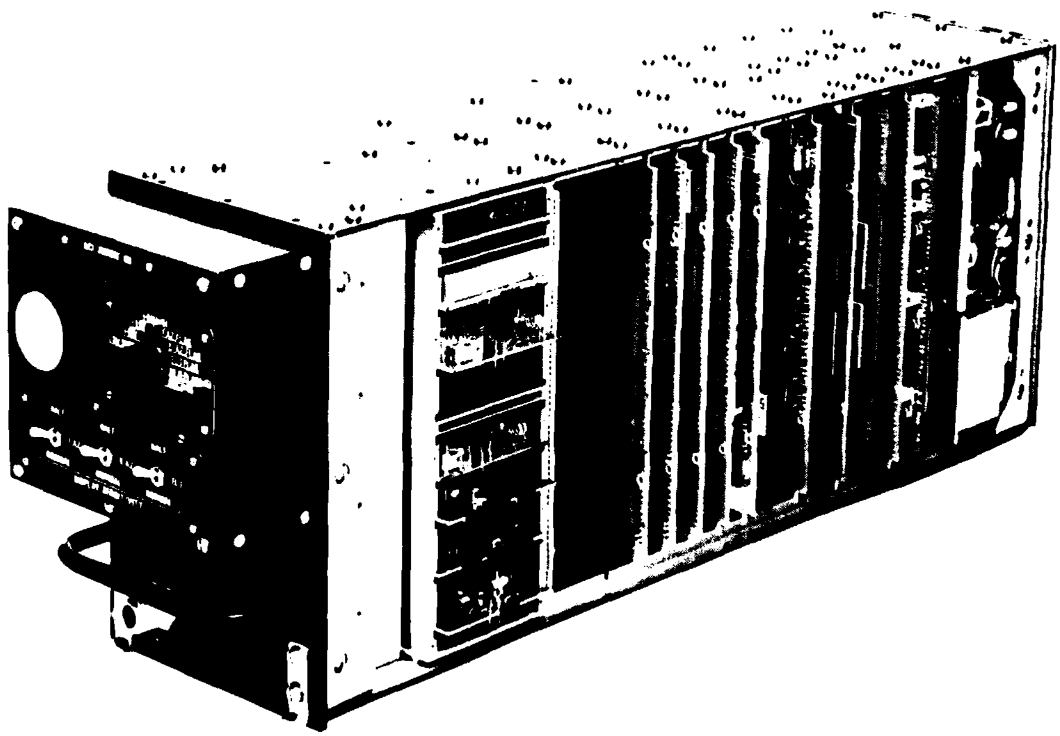

Fig 5.23b Internal view of receiver

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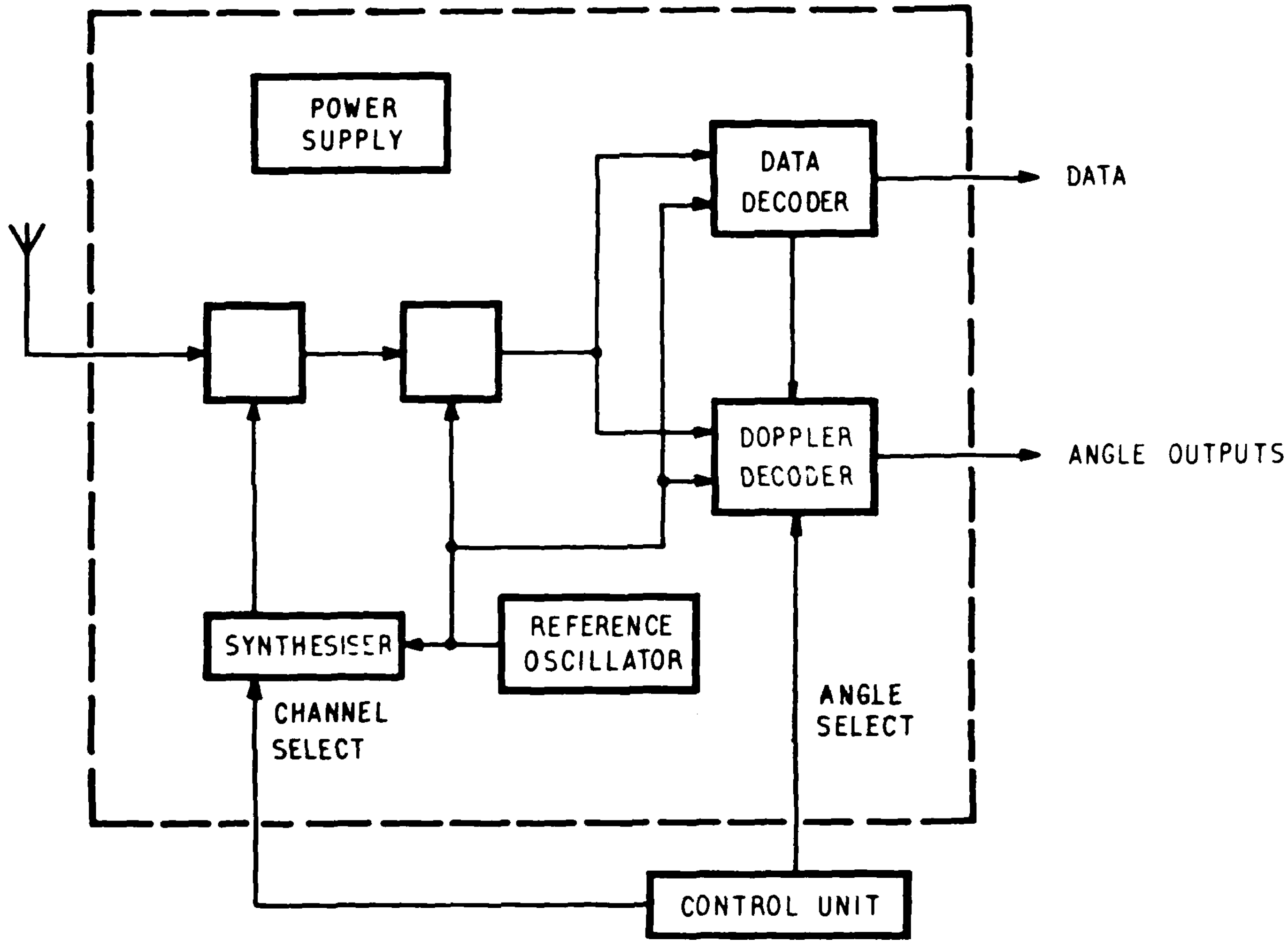


Fig 5.24 Block diagram for TDM receivers

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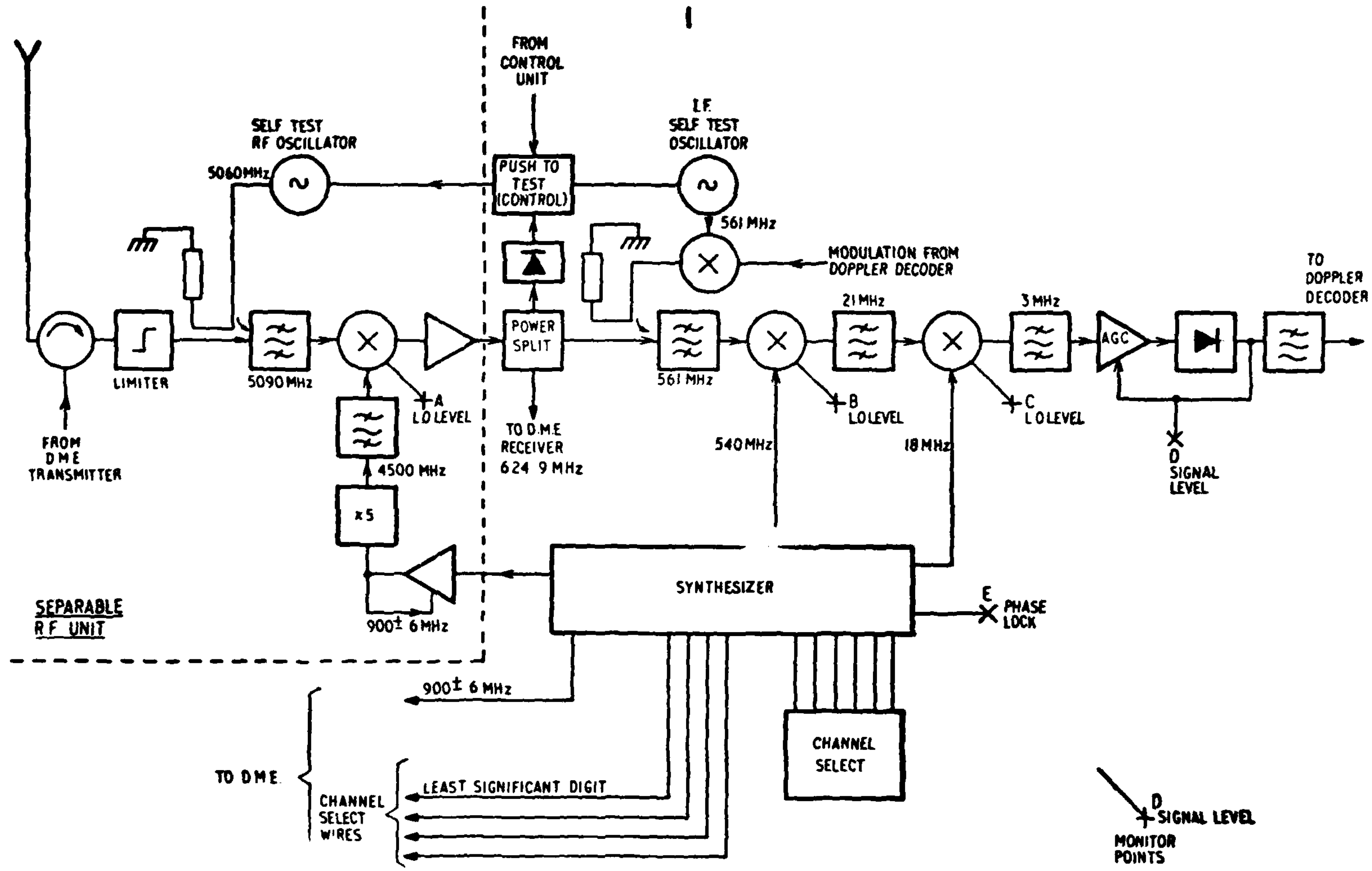


Fig 5.25 Receiver RF/IF circuits

Fig 5.26

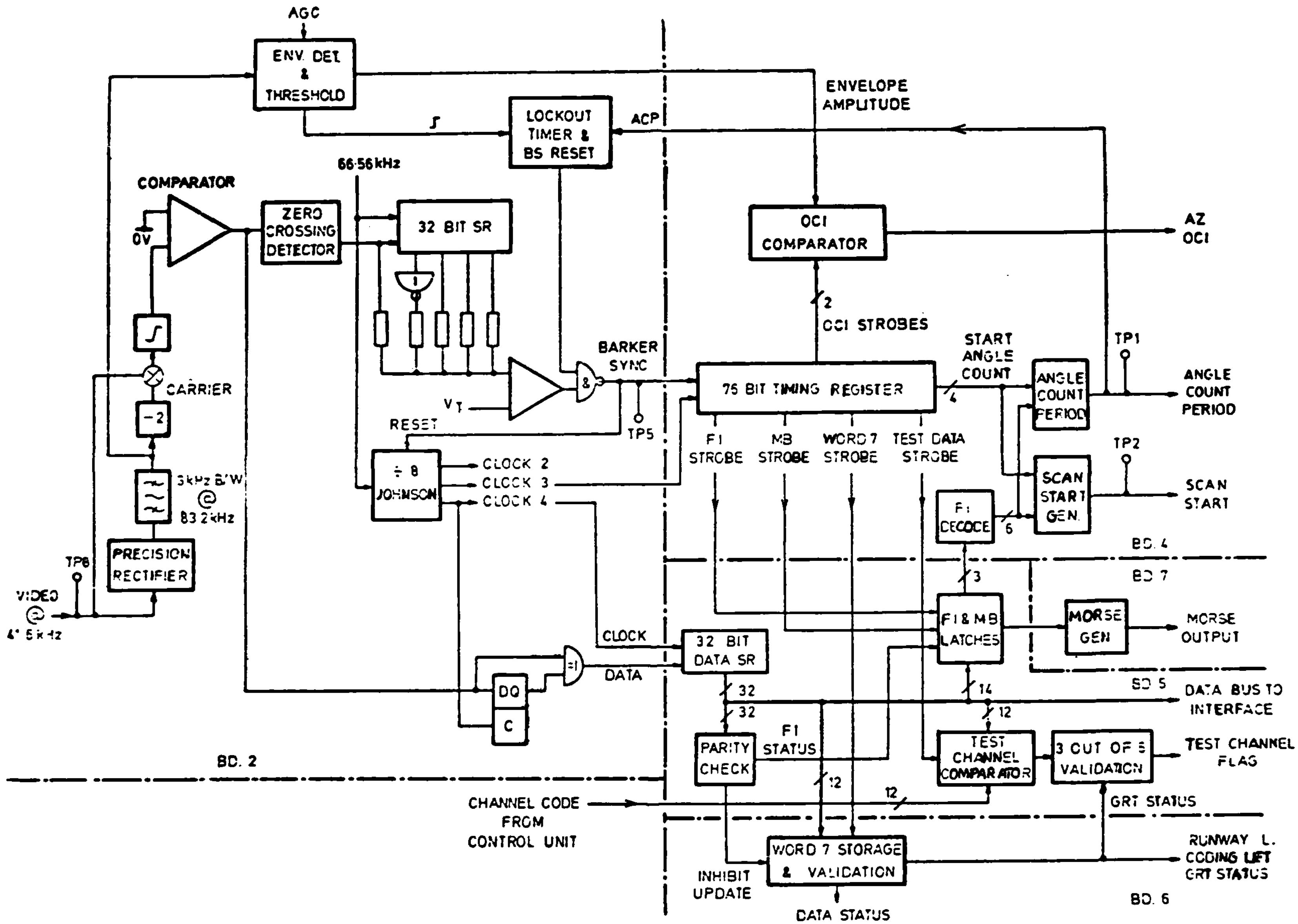


**Fig 5.26 Data demodulator and decoder**

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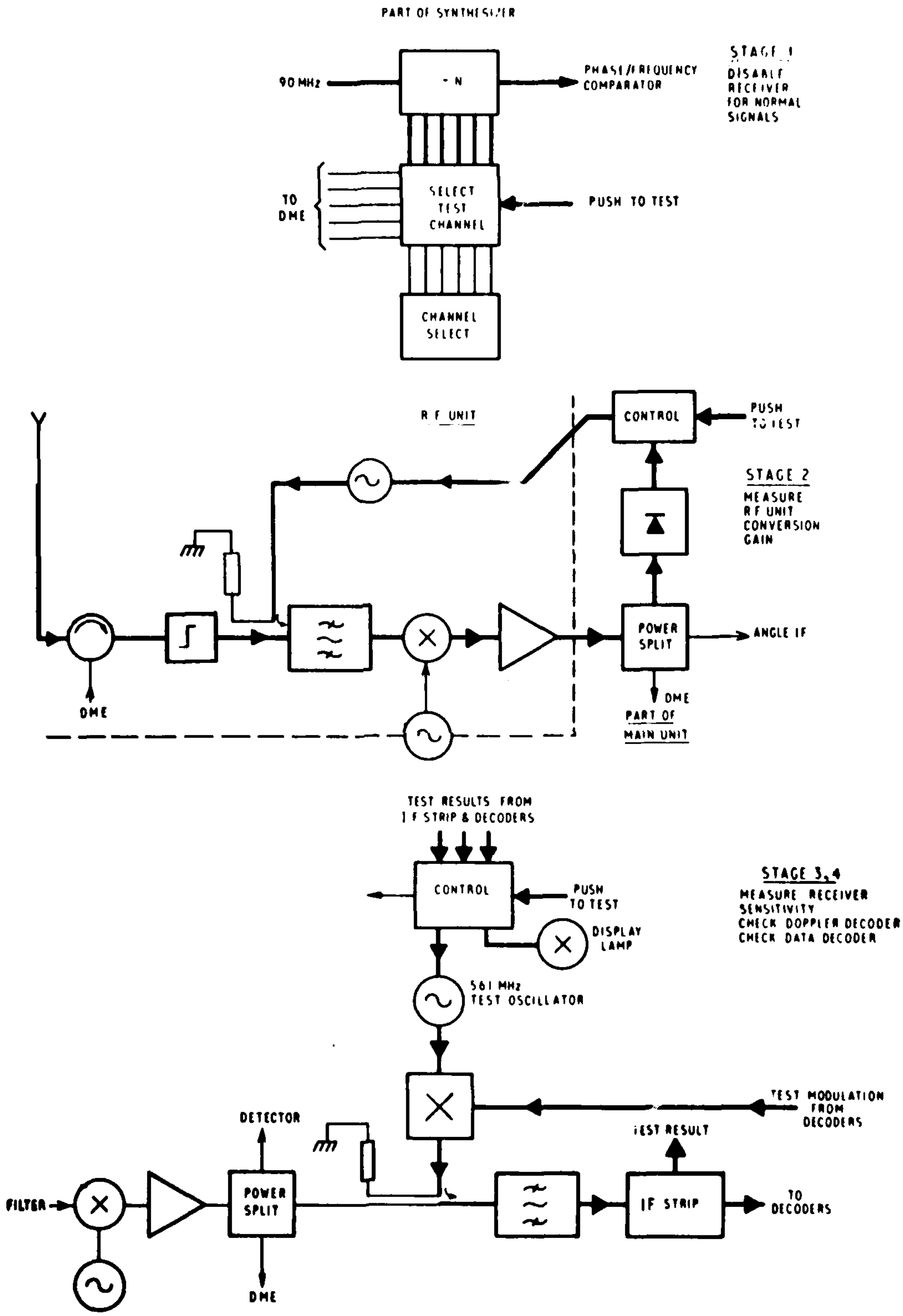


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Fig 5.27 RF/IF self test circuit

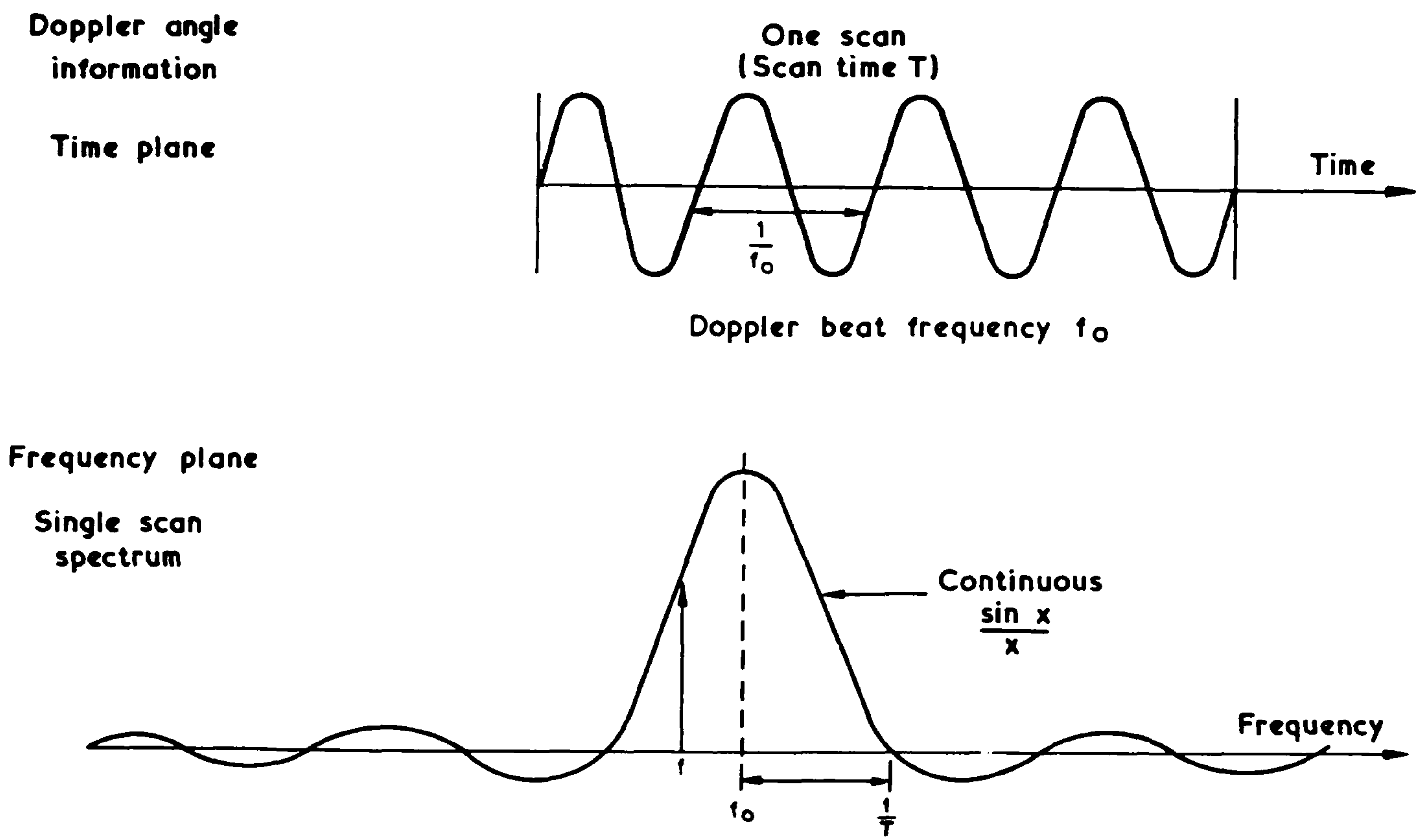


Fig 5.28 The Doppler signal

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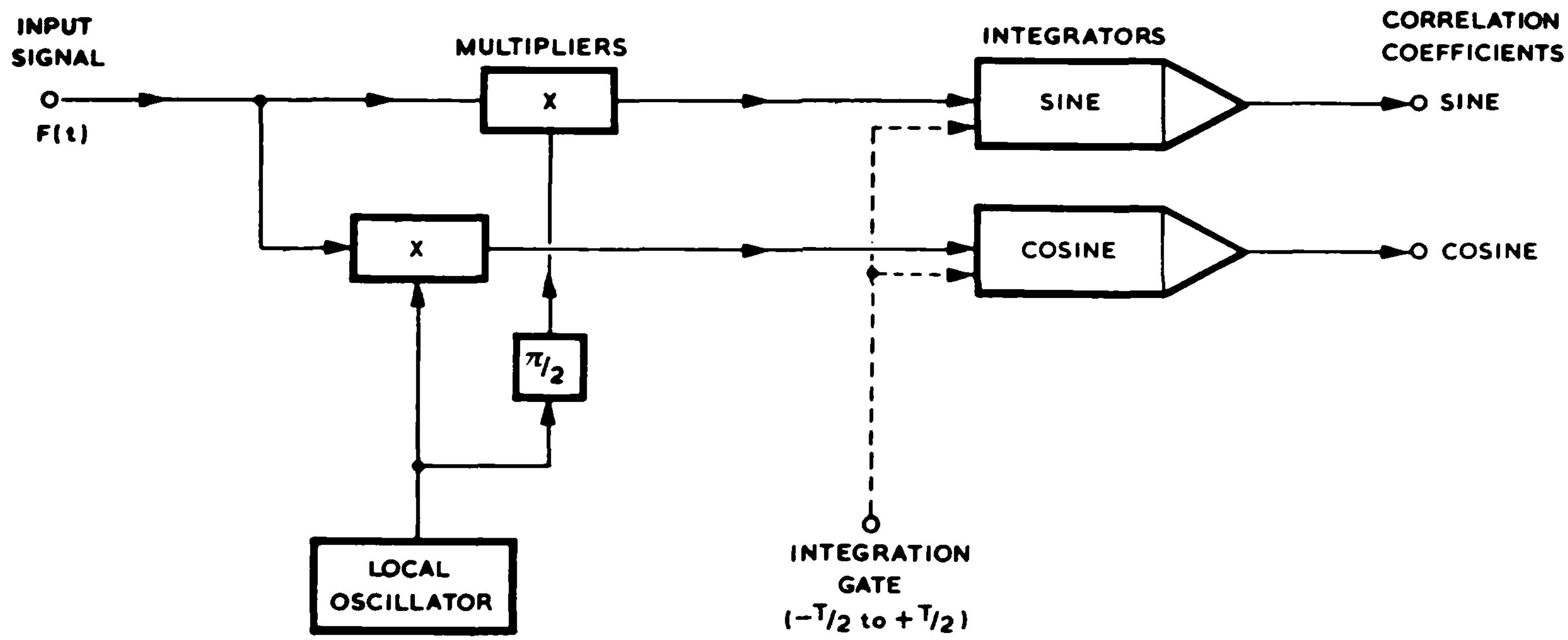



Fig 5.29 Single frequency analogue correlator

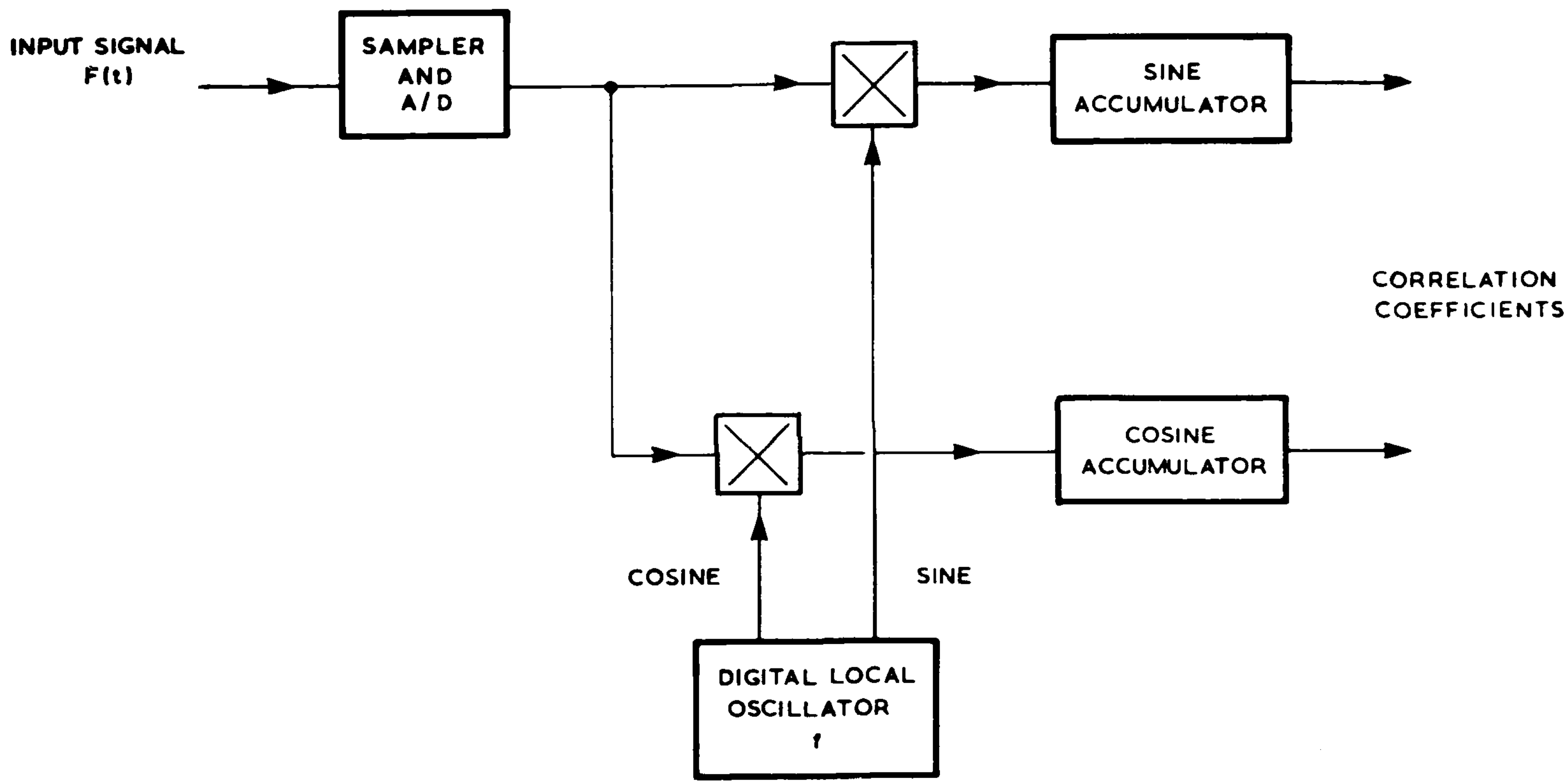



Fig 5.30 Digital frequency correlator

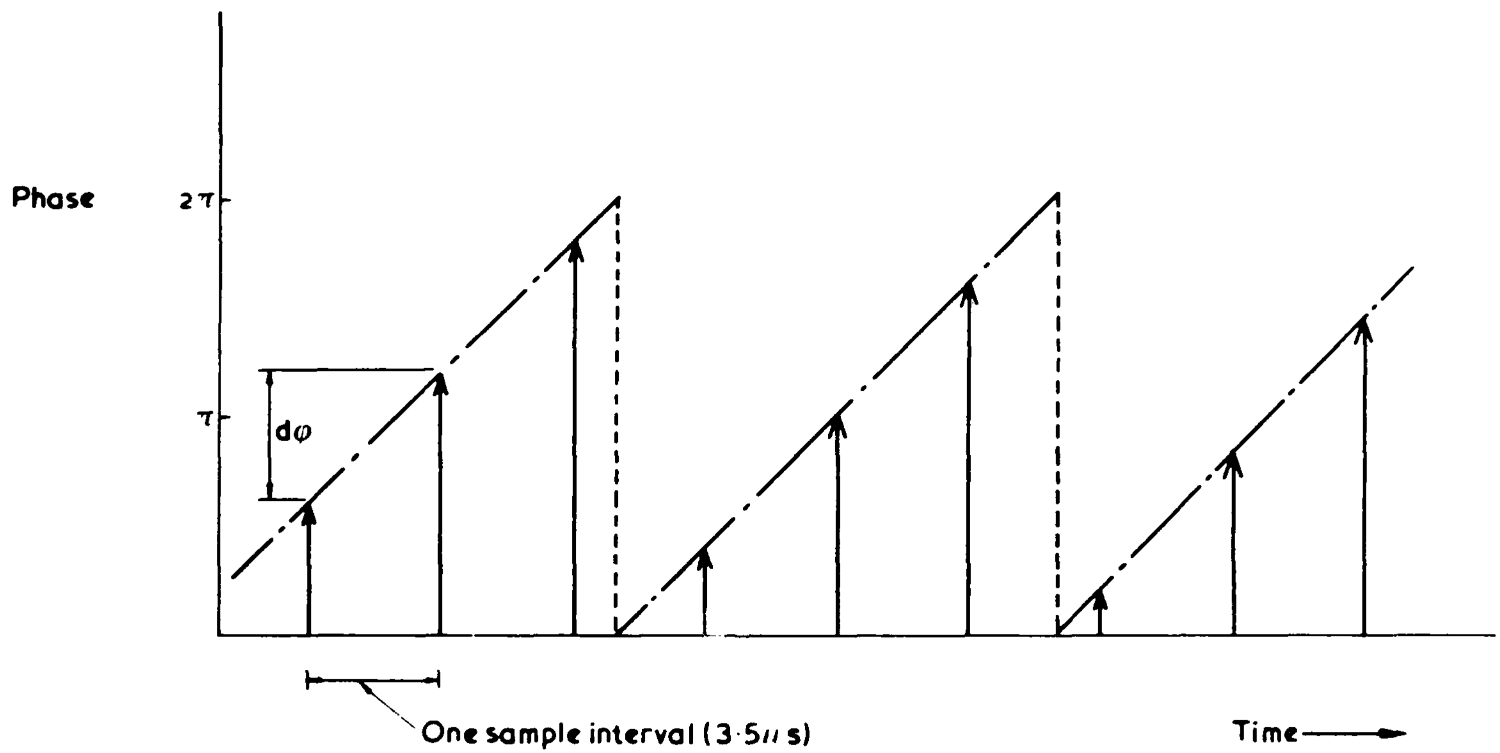



Fig 5.31 Digital frequency generation

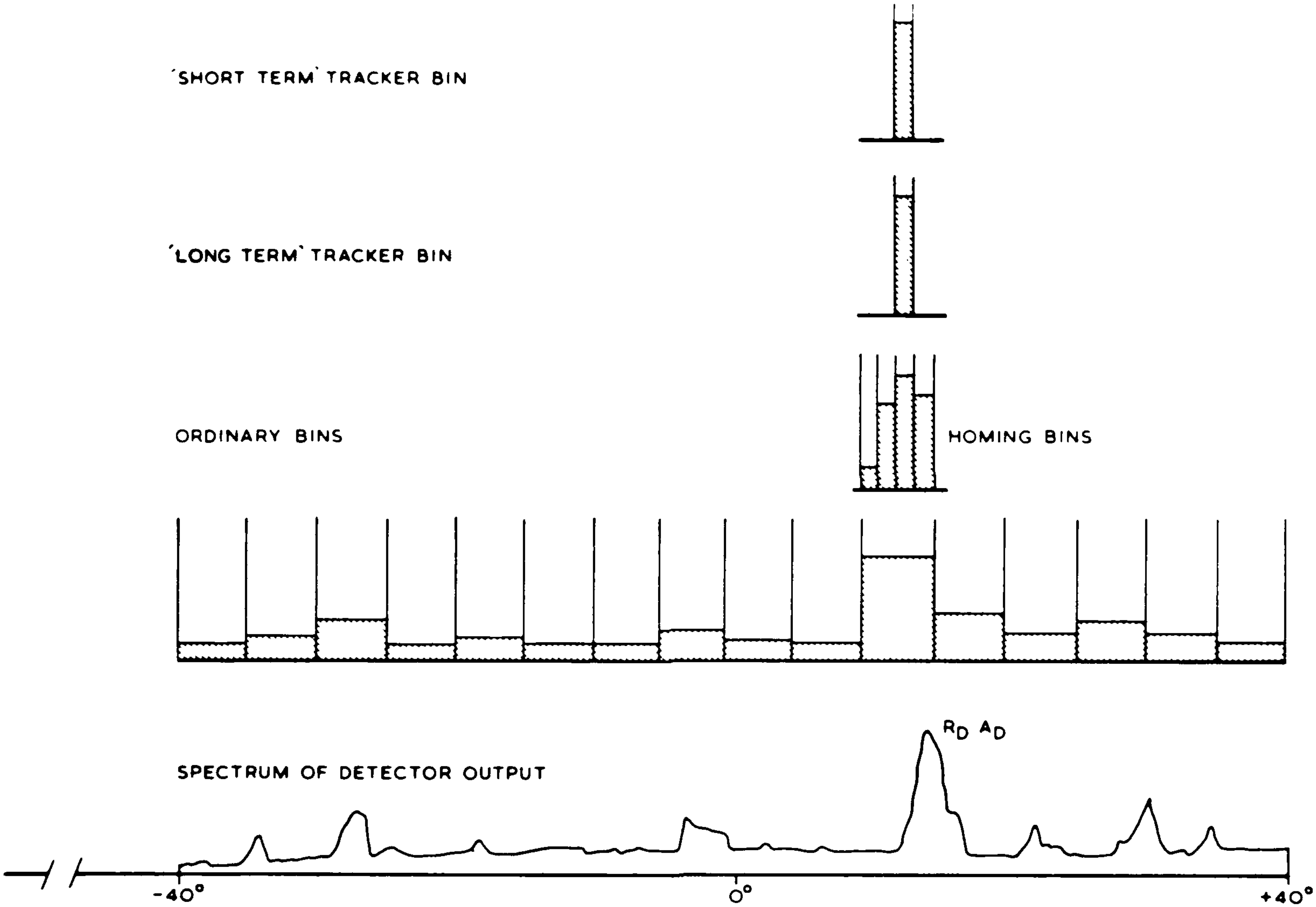



Fig 5.32 Correlator acquisition and validation process

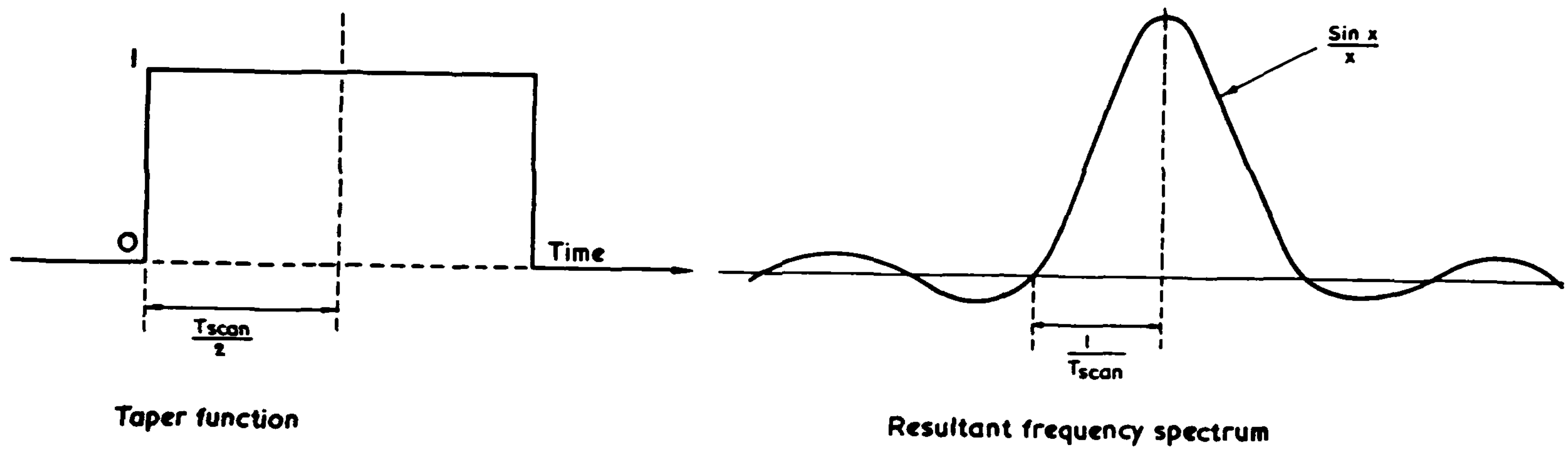
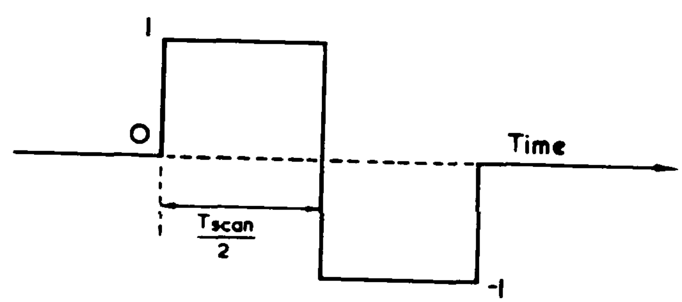
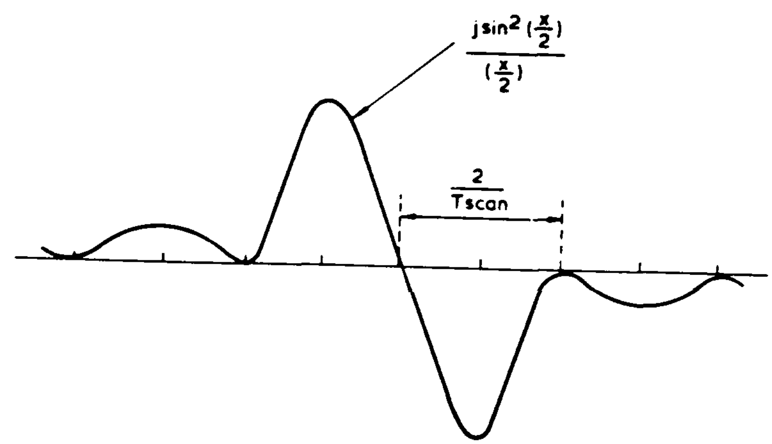



Fig 5.33 The frequency spectrum resulting from the use of a sum taper function




Taper function




Resultant frequency spectrum

**Fig 5.34 The frequency spectrum resulting from the use of a taper function difference**

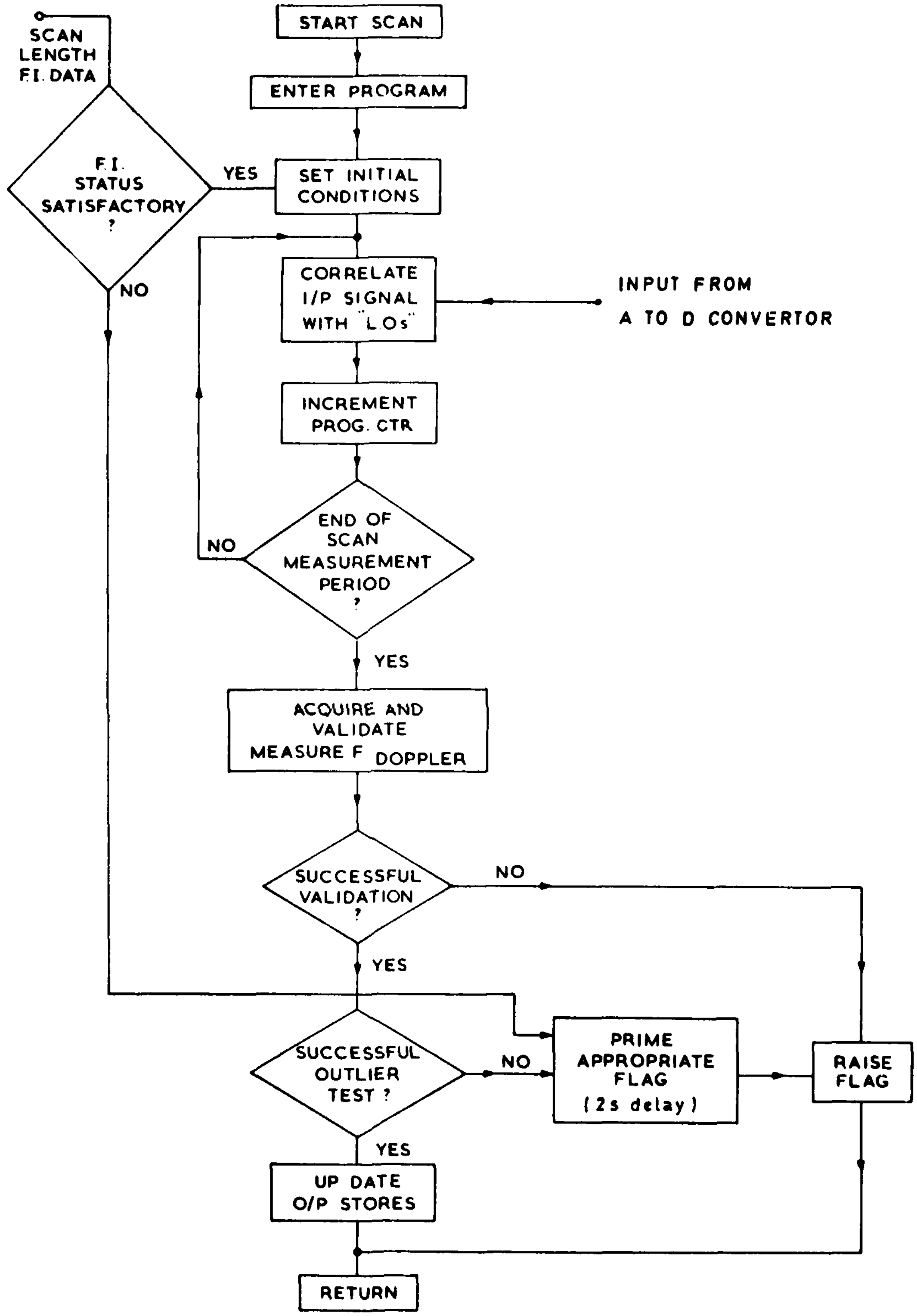



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Fig 5.35 Simple correlation system flow diagram

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